federal register

TUESDAY, JUNE 15, 1976

PART III:

DEPARTMENT OF LABOR

Occupational Safety and Health Administration

■

DIVING OPERATIONS

Emergency Temporary Standards

Title 29—Labor

CHAPTER XVII—OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION, DEPARTMENT OF LABOR

PART 1910—OCCUPATIONAL SAFETY AND HEALTH STANDARDS

Emergency Temporary Standard for Diving Operations

Pursuant to sections 6(c) and 8(c) of the Occupational Safety and Health Act of 1970 (the Act) (84 Stat. 1596, 1599; 29 U.S.C. 655, 657), Secretary of Labor's Order No. 8–76, and 29 CFR Part 1911, Part 1910 of Title 29, Code of Federal Regulations, is amended by adding a new occupational safety and health standard for diving operations as Subpart T, beginning at § 1910.401. The standard, set forth below is issued as an emergency temporary standard (ETS) and, in accordance with section 6(c) (2) and (3) of the Act, will be superseded by a permanent standard within six months. The standard takes effect on July 15, 1976, and applies to all employments covered by the Act.

Pursuant to section 6(c)(3), the Occupational Safety and Health Administration (OSHA) will shortly commence a rulemaking proceeding under section 6(b) of the Act. The ETS will serve as a proposed final rule, along with other subsidiary proposals which will be published pursuant to 29 CFR 1911.12. It is OSHA's intention to publish an additional proposal, encompassing those areas of occupational safety and health considered appropriate for the agency's permanent regulation of diving operations.

The development of a permanent standard will be conducted pursuant to section 6(b) of the Act, under which the Secretary's determination of the substantive provisions of the final standard will be based on the entire record developed, including public comments and, if requested, informal rulemaking hearings.

The United States Coast Guard which has jurisdiction over certain matters of maritime safety and health (see 40 FR 33681, August 11, 1975) will participate with OSHA in developing permanent occupational safety and health standards for diving operations. In order to maximize the resources and expertise available to the respective agencies, a joint rulemaking proceeding is contemplated. The Coast Guard has indicated its intention to promulgate under its statutory authority occupational safety and health standards applicable to diving operations from inspected vessels, in deepwater ports, and from artificial islands and structures on the Outer Continental Shelf.

Appended to this standard is a Memorandum of Understanding between OSHA and the Coast Guard setting forth certain procedures for coordination and joint activities during the effective period of the ETS and in developing permanent standards (Appendix A).

Of course, if appropriate, employers may seek temporary or permanent variances under the Act and implementing regulations during the period in which this ETS is in effect. Thus under section 6(b)(6)(A) of the Act and 29 CFR 1905.10, any employer may apply to the Secretary for a temporary order granting a variance from a standard or any provision thereof if he can establish that he is unable to comply with a standard by its effective date because of unavailability of professional or technical personnel or of materials and equipment needed to come into compliance with the standard or because necessary construction or alternation of facilities cannot be completed by the effective date, provided that he is taking all available steps to safeguard his employees against the hazards covered by the standard and he has an effective program for coming into compliance with the standard as quickly as practicable. Similarly, under section 6(d) of the Act and 29 CFR 1905.11, any affected employer may apply to the Secretary for a rule or order for a variance from a standard if he can demonstrate by a preponderance of the evidence that the conditions, practices, means, methods, operations, or processes used or proposed to be used by the employer will provide employment and places of employment to his employees which are as safe and healthful as these which would prevail if he complied with the standard.

Background

On August 8, 1975, the United Brotherhood of Carpenters and Joiners of America, AFL–CIO, filed a petition, requesting that the Occupational Safety and Health Administration issue an emergency temporary standard for commercial diving operations within the United States and its coastal waters, including those located on the Outer Continental Shelf. The petition alleged that American divers, some of whom are memers of petitioner's union, are exposed to grave danger and that an ETS is necessary to protect commercial divers on offshore oil exploration projects and in other operations from toxic gas, chemical, and pressure exposures which in the aggregate create a hostile and dangerous environment adversely affecting diver safety and health (Exh. 1).

The petition urged the Secretary to issue a comprehensive diving standard substantively based on the following:

(1) The American National Standards Institute (ANSI) Z–135 Standard for Diving (modified Draft #13);

(2) The U.S. Navy Standard Air Decompression Table (Repetitive Group "O") for dives not in excess of 190 feet;

(3) The U.S. Navy Surface Decompression Tables, excluding all "exceptional exposure dives;"

(4) A procedure for 21 days' advance validation by the Secretary of Labor of diving tables outside of U.S. Navy optimum dive tables;

(5) The "Compressed Air for Human Respiration" standard of the Compressed Gas Association (Pamphlet G–7); and

(6) The "Commodity Specification for Air" standard of the Compressed Gas Association (Pamphlet G–7.1).

After review of the petition and supporting evidence by OSHA staff, and consultation with the petitioner and other parties having potentially adverse interests, the Secretary concluded that the public interest would be served by holding an OSHA fact-finding hearing. The hearing was to accomplish two objectives—to ascertain the nature and extent of the occupational safety and health hazards associated with diving operations, and to provide a basis for determining the appropriateness of an ETS for diving. Public announcement of the hearings was made in the FEDERAL REGISTER (40 FR 49123, October 22, 1975).

The hearings, presided over by a Department of Labor Administrative Law Judge, were held during a four-day period, November 11–14, 1975, in Washington, D.C. Evidence was presented by twenty-five witnesses producing some 874 pages of recorded transcript. The witnesses included: several medical experts experienced in hyperbaric medicine from the United States, and one from the United Kingdom; diving contractors representing both large and small firms located throughout the country (East Coast, Great Lakes, Gulf States, and the West Coast); academic and independent research physiologists experienced in the formulation of diving tables and work practice protocols; commercial divers and other diving personnel, some of whom had sustained employment related injuries; diving program administrators; maritime attorneys familiar with the legal aspects of diving-related personal injuries; representatives of the petitioner (United Brotherhood of Carpenters and Joiners, AFL–CIO) and the principal industry trade association (Association of Diving Contractors); and representatives of government agencies with personnel engaged in diving. Government submissions were received from the U.S. Navy, the U.S. Coast Guard, the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce, the Bureau of Land Management of the Department of Interior, and the National Park Service also of the Interior Department.

In addition, a large number of parties elected to supply written comments in lieu of oral testimony. Documents and exhibits were also supplied in great numbers from witnesses and other interested persons. All participants were given until December 8, 1975, to submit post-hearing comments.

Shortly after the conclusion of OSHA's public fact-finding inquiry, the Department of Labor assembled a Federal agency task force to outline the contents of possible government diving regulations. In addition to OSHA, members of the group represented the National Institute for Occupational Safety and Health (NIOSH), the U.S. Coast Guard, the Navy, and NOAA. All participants had been either experienced in, or associated with, diving for a number of years. The task force also retained and consulted with outside diving experts. These experts represented a cross-section of skills, experience, and training, including expertise in hyperbaric medicine, physiology, the development

of diving tables and other diving protocols and in a wide variety of operational diving modes and techniques.

Substantial technical input was provided by the diving research group of NIOSH and its contractor, the Undersea Medical Society, with the formulation of a "National Plan for Safety and Health of Divers in the Quest for Subsea Energy" (Contract No. 210–75–0073, January 1976, hereinafter "NIOSH I"). In addition, OSHA has had the benefit of the preliminary work product of a second NIOSH diving project, "Safe Work Practices and Medical Procedures" (April-May 1976, hereinafter "NIOSH II").

Supplementing the testimony obtained from the fact-finding inquiry and the technical assistance received from various government agencies and outside consultants, OSHA has had the opportunity to evaluate a considerable amount of documentary material relating to diving safety and health (see attached list of references). Particular attention has been given to the following major documents: the diving manuals of the U.S. Navy, NOAA, and the Association of Diving Contractors (ADC); draft proposals of the ANSI Z–135 Standards Committee for Commercial Diving Safety; diving regulations from several foreign countries including the United Kingdom, Australia, France and Canada; state diving codes of Oregon and Florida; and the medical and scientific papers of symposia devoted to diving safety and health. In addition, many members of the diving community with significant expertise and interest in diving safety and health have continued to make their experience and views available to the agency.

FINDINGS AND DETERMINATIONS

The Assistant Secretary has reviewed the entire record and evaluated all pertinent materials available to the Department with respect to occupational safety and health hazards associated with diving. The Assistant Secretary finds that divers work in an underwater environment which is inherently hazardous, and are subject to working conditions which pose life threatening risks on a daily basis. Because of the nearly complete absence of regulatory safeguards to protect them against these inherently hazardous working conditions, the Assistant Secretary has determined that such divers are exposed to a grave danger from exposure to substances or agents which are toxic or physically harmful within the meaning of section 6(c)(1)(A) of the Act (29 U.S.C. 655(c)(1)(A)).

The Assistant Secretary also finds, based on the evidence in the record, that unsafe work practices exist in the diving industry which have caused, and unless abated, will continue to cause serious injury, permanent disability and death among members of the diving community. Such practices increase both the gravity of the dangers to which divers are exposed, and the urgency of the need for immediate occupational safety and health regulations.

In addition, the Assistant Secretary has also concluded that, as a result of heightened activity in recent years in the diving industry primarily attributable to the nation's need to secure additional energy and mineral resources. divers are now being exposed to increased safety and health risks. These new risks are associated with, among other things, deeper and longer dives, the use of new operational modes and techniques, diving tables, and breathing mixtures which have not been tested to the same extent as previously. The Assistant Secretary has determined that these circumstances further require issuance of this emergency temporary standard because their existence augments both the inherent high risk and the existence of unsafe practices within the industry. The Assistant Secretary has further determined that such circumstances in themselves constitute a grave danger from exposure to new hazards within the meaning of section 6(c)(1)(A).

The Assistant Secretary has further determined that the issuance of an emergency temporary standard at this time is the required statutory response to the existence of the grave danger from exposure within the diving industry and that this ETS is necessary to protect divers from the grave dangers to which their occupation subjects them.

1. *Inherent danger and absence of regulation.* Working in an underwater environment is inherently hazardous in that it subjects divers continually to life-threatening safety and health hazards including several toxic substances and harmful physical agents.

Because of the hostile environment in which he works, the diver's place of employment is unique among all occupations. Divers must at all times be protected against harmful physical agents such as high pressure, temperature extremes, and unpredictable sea states. Toxic substances, due to contaminated breathing mixtures and the dependence on compressed gases, subject the diver's entire body to abnormal stress, organ dysfunction, sensory derangement, and other adverse physiological changes. In order to accomplish their work mission divers must be equipped with various types of tools such as oxy-arc cutting instruments, electric arc welders, and various explosive devices which can be hazardous in and of themselves; any faulty and improper equipment necessarily compounds the risk of danger. In addition, the diver is faced with many other hazards such as falling, loose, or sharp underwater objects which can crush, cut, or foul the diver's gear. Because the diver's work is in an isolated environment, even otherwise minor accidents can result in major tragedies unless medical assistance and treatment is obtained quickly.

Protection against these and the other hazards divers face can be afforded only by following the various procedures, equipment, and competence standards. A diver's well-being depends on the diver's protective equipment and the apparatus used to supply him with a life sustaining gas mixture, the diver's own competence and experience as well as the competence of his support team, the diving procedures used to permit the diving operation to be carried out safely, and the emergency procedures to be used if an accident should occur. A failure of any of these elements could be disastrous for the diver. The tolerances for error may be very slight. For example, in very deep dives a change of as little as one quarter of one percent in the proportion of oxygen in the diver's breathing mixture can mean the difference between death and survival (Tr. 46).

These factors—the diver's exposure to the unique hazards of undersea activity, his isolation from aid in the event of an accident or injury, the complex nature of his protective system, and the slight tolerance for error which exists in the operation of that system—all combine to create a situation in which the potential for serious or fatal injury to the diver is great. The factors creating this potential are present in few if any other occupations.

The total absence of any uniform and enforceable occupational safety and health diving standards places divers in increased jeopardy. There are no comprehensive occupational safety and health regulations applicable to the diving industry. A voluntary code has been established by the Association of Diving Contractors (ADC), but no uniform standards exist which are capable of being enforced or have application throughout the diving industry. Although a few states such as Oregon and Florida have promulgated diving safety codes, other states with significant diving populations have not. Compounding the problem is the fact that much of the diving which is currently done and most of the increased diving activity will be in areas which are outside the jurisdiction of individual states. Therefore only Federal agencies with appropriately comprehensive jurisdiction and authority are capable of addressing the problem of diving safety and health on a nation-wide basis.

Promulgation of an ETS for diving is necessary under the aforementioned circumstances in order to reduce the existing and future exposures to grave dangers. Pursuing regulatory strategies of either no regulation or delayed promulgation would have resulted in the increased likelihood of irreparable injury to significant portions of the diving population, and have been otherwise contrary to the agency's statutory responsibilities and basic policies of the Act.

Because of the inherent hazards associated with diving, the likelihood of increased activity with high risk potential, and the absence of any enforceable standards within this area, immediate adoption of an occupational safety and health standard is considered critical to the affected diving population. Fur-

ther delay in the promulgation of an appropriate OSHA standard would be unjustifiable in light of the high risk potential of the industry. The Assistant Secretary believes the decision to issue an emergency temporary standard is fully in consonance with the goal of the Act to assure safe and healthful working conditions.

2. *Occurrence of unsafe practices.* It is clear that there are now occurring within the diving industry unsafe practices which cause and threaten to continue to cause serious injury and even death.

Diving is a highly competitive industry which has been in a period of rapid expansion. There is demand for more diving, deeper diving, and longer diving. While employers are concerned with employee safety and health, the economic pressures are such as to provide a temptation to underbid competitors at the expense of safety and health considerations. Evidence presented at the hearing indicated that this is a significant problem (e.g., Tr. 303, 595, 601).

Training, experience, and physical fitness are clearly major factors in diver safety; yet employers have acknowledged their difficulty in recruiting divers who are sufficiently qualified to perform the types of diving activities which the employers are now contracting to perform (Tr. 151–54, 637–38). As a result, employees who lack the necessary competence to perform their dive or underwater work task safely have been exposed to situations which were too difficult for their level of skills (Tr. 566, 601–603). Not only are some of the divers unqualified, but some diving supervisors apparently lack the necessary competence as well (e.g., Tr. 543, 594, 619). Even when an employer establishes, by a manual or otherwise, a system of safe practices, unless there is a requirement to follow them, diving supervisors and other employees may act in a contrary fashion (Tr. 155–156). Likewise, the ADC Manual is a document which is not agreed to in all of its respects by all ADC members (e.g., Tr. 161), is not presently enforceable against any member who deviates from it (Tr. 830–831), and of course is not binding on the many diving contractors unaffiliated with the ADC. Consequently, as a result of deviations from accepted safe practices, there have been instances of diving operations in which divers have been permitted to dive below 220 FSW without any bell (Tr. 316, 544, 546, 550–53, 591–92, 595–6, 617, Exh. 47); untested diving tables are in use (Tr. 262); appropriate diving tables are present but have not been properly used or followed (Tr. 541, 543, 594, 629); or there has been no protective device to keep the propellers from cutting or entangling a diver's umbilical during live-boating (Tr. 341–42, 544–48, 595). Some of these incidents have ended in tragedy. (Exhs. 11, 41, 44, 45, 47–50; PHC 13, 14 (appendices); Reference M).

Moreover, in addition to such instances of unsafe work practices, other circumstances, including lack of a decompression chamber for onsite recompression treatment, inadequate diving platforms and barge layouts, and inadequate communications, have also been identified as contributing to diving accidents (Tr. 258–59). It has further been reported that equipment failure and equipment misuse have been at the root of many accidents, and that inadequate training of the persons involved was to a large extent responsible for this situation (Tr. 163).

These same factors which currently lead to certain unsafe practices are likely to be exacerbated as the diving industry expands into newer, deeper, and more complex areas. The situation will likely result in the involvement of more employers and divers who lack the experience and competence to do the kind of sophisticated work required, and will create further competitive pressures to reduce margins of safety in work operations. As one expert witness testified:

> It does not take much foresight to make three basic predictions for 1976 and the years that follow: (1) The quantity of diving in American waters will increase as the incentives for exploration follow rising petroleum needs; (2) the standard offshore diving setup will have 1,000 to 1,200 foot capability and these capabilities will be used; and (3) more divers will die (Tr. 14).

The evidence shows that some divers have already been killed or seriously injured in the course of their employment. The record indicated a number of deaths and serious injuries associated with diving which were related to or arose out of the course of employment (Exhs. 11, 41, 44, 45, 47–50; PHC 13, 14 (appendices)). While the testimony elicited at the fact finding hearing produced conflicting statistical evidence as to specific mortality and morbidity rates, the Assistant Secretary concludes that there is substantial evidence to support a finding that work-related hazards have manifested themselves as disabling injuries, illnesses and fatalities. The Secretary believes that examination of U.S. Coast Guard investigations of divers' deaths supports this conclusion.

The Assistant Secretary therefore finds as a result of these unsafe practices that divers are actually exposed, and will continue to be exposed with increased frequency, to grave dangers in their work. This factor further compels the conclusion that action pursuant to section 6(c) of the Act is warranted.

3. *New hazards occasioned by industry expansion.* As a result of heightened activity in the industry, divers are being exposed to new safety and health risks. Primarily as a result of the nations' need to secure new energy and mineral resources, the diving industry has been the scene recently of rapid expansion on submerged coastal lands and those further off shore on the Outer Continental Shelf. During all phases of operations, divers play a critical role. Consequently, such operations are requiring dives which are deeper, more frequent, and of longer duration than ever before. These extremely deep diving operations will continue because of the locations of many of the new areas set aside for exploration and production. Because of operational complexities, it is necessary for such diving often to be done for long periods of time. There is a clear likelihood that this trend will extend into the foreseeable future. As a result of this heightened intensity divers are being subjected to greater stress and fatigue, which further increase the risk of hazards usually present and associated with diving, per se. This new activity also raises the opportunity for diver exposure to long term hazards such as adversely subtle physiological changes, and diseases such as osteonecrosis (NIOSH I, 2–1, 3–1, et seq.).

The development and increasing use of new diving technology and operational modes has caused a re-evaluation of previously known hazards, and has resulted in the emergence of new health hazards which have the capability of affecting the diver's health.

The nature of off-shore activity has brought about the use of relatively new diving techniques and operational equipment. Deep dives of longer duration and involving complex underwater tasks are utilizing with increasing frequency saturation or saturation-excursion mode diving in which divers work and live under a highly pressurized environment for prolonged periods of time. While this mode does offer distinct operational advantages, it nevertheless creates exposures to new hazards, and has caused a re-examination of known hazards. In the deeper diving modes, exotic mixtures of inert gases are required to maintain environmental balance and the life support of divers. A miscalculation in adjusting the breathing mixture could cause tragedy. Highly precise decompression protocols must be employed in order to safely remove the diver from his pressurized surroundings. Prolonged exposure under pressure has caused re-evaluation of existing decompression sickness etiology. High Pressure Nervous Syndrome is one of the likely occurrences if the proper precautions during compression are not taken. (NIOSH I, 12–1, et seq.) New concern has been raised with respect to emotional stress and chronic fatigue to long term confinement. (NIOSH I, 5–1, et seq.)

Further industry expansion is virtually certain, making it increasingly difficult for diving employers to secure either adequately trained personnel, or, apparently, the equipment necessary to do the newly required operations in a safe manner.

All available data indicates a clear trend toward the increasing need for commercial divers, especially those with deep sea experience. However, there exists only a limited number of personnel who are adequately trained to accomplish the complex and demanding tasks associated with off-shore operations. Because of the nature of these operations, increasing numbers of competent and experienced surface support personnel will also be needed. The record indicates that poorly trained and inexperienced persons are significant factors in diving accident causation (e.g. Tr. 151–54, 637–38). The lack of qualified persons,

specifically trained for deep diving operations, is likely to cause an increased incidence of mortality and morbidity. This increased demand for deeper diving is likely to place some employers in a position where they will be unfamiliar with the newer operational modes, and unable to secure the proper equipment necessary to perform a particular operation in a safe manner. An absence of appropriate equipment or the presence of poorly maintained equipment will pose a definite hazard to affected workers.

The nature and scope of projected diving activity in the United States is analogous to that in other parts of the world, where there have been marked rises in fatalities, serious injuries and diving related illnesses.

The agency has taken note of the increase in accidents in international diving which has paralleled a rise in international diving activity similar to the increase in diving activity which is taking place in this country. As of January, 1976, at least 27 divers were reported to have been killed in the European North Sea operations over a four-year period, and almost half the number died in 1975 alone. This mortality rate is even more significant given the fact that the North Sea diver population is just over 1000, and has a fatality rate of 10 per 1000 for North Sea divers which represents a rate 220 times than that for factory workers (Tr. 117,256; Exhs. 44, 45; PHC 6, Reference N). Although not within the jurisdiction of OSHA regulations, many of the activities in these areas are conducted either directly by, or through affiliates of, American companies. In addition, many of the persons who dive in these foreign waters, are the same ones who dive in American waters.

Despite some differences in environment and climatic conditions, the foreign operations are in many respects similar to those being conducted here, or similar to those likely to be operated here in the near future (NIOSH I, xv-xvi).

For the reasons set out above, the Secretary concludes that the nature and intensity of the diving industry's recent activities have subjected, and are likely to continue to subject, divers to new hazards within the meaning of section 6(c)(1)(A) of the Act.

4. *The standard is necessary to protect divers from grave danger.* All aspects of the standard are necessary to protect divers from the grave dangers to which their occupation subjects them. These myriad hazards stem from the fact that once a diver descends into the water his safety, and ultimately his life, depend on the proper functioning of his equipment and the carrying out of safe practices. This system includes the competence, training and physical fitness of the diver; the competence and training of the diver's support personnel; the operating procedures used to assure that the diver is not unnecessarily exposed to unsafe situations; the equipment needed to protect the diver from the hostile undersea environment; and a means to monitor and record the time-pressure-gas mixture exposure. A failure in any of these elements exposes the diver to grave and potentially fatal dangers. Accordingly, to protect divers from these grave dangers the standard must, and does, ensure the adequacy of all these components.

The dangerous consequences of a failure of any of these components are described in detail later in this preamble as are the ways in which the standard responds to those hazards. A few examples are cited to illustrate that a diver is only as safe as the weakest link in this chain of components and that in order to protect divers from the grave dangers inherent in their occupation the standard must cover all of those links.

First, the standard has various requirements designed to ensure that all personnel, including divers and the support team, are adequately trained and competent to perform their assigned tasks. Such competence is vital to diver safety. For instance, an inadequately trained diver may, in a moment of panic, hold his breath during ascent from a dive (Tr. 198–200). Doing so, even during a relatively short ascent from shallow water will subject the diver to a possible gas embolism, a serious condition in which gas bubbles are forced into the bloodstream and can block bloodflow to the brain and other organs (Tr. 46; Exh. 6, 3–23, 8–9; NIOSH II, E–43). The standard addresses this danger by requiring employers to ensure that divers have a working knowledge of physiology as it applies to diving.

Second, the standard requires that divers be medically fit to dive. A person who, for example, is chronically unable to equalize sinus or middle ear pressure risks severe damage to those organs by subjecting himself to the increases in pressure inherent in diving (Exh. 6, 3–18–20). The standard prohibits a person with a chronic condition of this type from diving.

Third, the standard contains provisions to insure that safe operating procedures are employed. Without such procedures diver safety is impossible. For example, a diver engaged in a deep dive requiring long decompression time is isolated from surface assistance because he cannot ascend rapidly without suffering severe decompression sickness. If, therefore, he cuts himself badly or breaks a leg he may die from blood loss or shock before he can be safely brought to the surface (e.g. Tr. 592–3). To protect against this danger the standard requires the use of diving bells with standby divers for specified deep dives. The bell provides a safe refuge in which the injured diver can be treated.

Fourth, the standard requires that equipment and tools used in diving operations be appropriate and well maintained. A failure in almost any piece of the necessary equipment is potentially disastrous. For example, a malfunctioning air compressor which becomes overheated or pumps lubricating oil can introduce a level of carbon monoxide or oil mist in the respirable air that will affect the health or even imperil the life of the diver. The standard attempts to prevent such problems by requiring a prescribed level of respirable air purity fed to the diver.

As the preceding examples illustrate, a diver's safety from the grave dangers he faces on his job depends on safe practices, equipment, and levels of competence; and to protect divers the standard must cover each of those components.

5. *The standard can be readily implemented.* To assure compliance on an almost immediate basis (a 30-day delay in the effective date is provided to permit familiarization with the standard), only the most basic and minimum requirements necessary for assurance of safe and healthful working conditions, and other corollary rules necessary to assure that these requirements are properly maintained, have been included in the emergency temporary standard. Because of the unique and highly specialized nature of diving operations, OSHA obtained considerable technical advice from various members of the diving community including information regarding the capability of the industry to comply with the standard. Based on this information, the Assistant Secretary has concluded that the standard can be readily complied with. This conclusion that requirements of this emergency regulation can be readily implemented without significantly affecting the operations within the diving community as a whole is supported in part by the fact that much of the standard is based upon the ANSI Z–135 draft standard and the ADC Manual of Safe Diving Practices. This fact indicates that most of the requirements of the standard will be familiar to employers and that the types of requirements imposed by this ETS are considered generally feasible by the industry itself.

The basis for these findings and a fuller discussion of the hazards and the necessity for the standard are contained in the sections which follow.

Nature of the Diving Industry

According to a March 1975 census taken by NOAA, the commercial diving population in the United States numbers 2305. Commercial divers perform a variety of underwater tasks, and may be engaged in diving in any the country's coastal waters, the Outer Continental Shelf (OCS), throughout the Great Lakes region, and in many of the nation's rivers and inland lakes (Exh. 12).

As reported by the Undersea Medical Society, prior to about 1960 almost all commercial diving in the United States centered around harbor areas and inland waterways, and consisted mainly of construction, repair and salvage work. Until that time, except for scientific exploration and occasional salvage operations, the United States Navy did the bulk of the country's deep-sea diving. However, within the past decade and a half, in conjunction with this nation's quest for expansion of its share of the world's energy and mineral resources, new areas, mainly those located in coastal waters and other further off-shore areas have been opened for exploitation. Recent international

political and economic circumstances have caused this trend to be accelerated (NIOSH I, A–1).

According to the U.S. Department of Interior's Bureau of Land Management, there are currently over 2,000 oil and gas producing facilities in the Gulf of Mexico, and an additional five off California's Santa Barbara channel (Tr. 17). NOAA places the present diver population in the Gulf of Mexico at 905 full-time and 450 part-time divers (Exh. 12, Table 2, p. 7). Several states, namely Alaska, California, Texas and Louisiana have recently proceeded to expand their off-shore leasing activities. In addition, the Federal government has initiated a program of leasing new sections of the Outer Continental Shelf (Tr. 14–31; Exhs. 23, 24). Sales have recently been made off the West Coast near Southern California, and sites along the mid-Atlantic Coast (Baltimore Canyon) and in the Gulf of Alaska are scheduled for leasing during 1976. Although water depths of the Baltimore Canyon area range from 130–500 feet seawater (FSW), the ocean floor in the area of the new Southern California leases is 650 FSW at its shallowest and in some places exceeds 2,400 FSW. Of the six most recent lease proposals, the water depth for potential oil and gas exploration exceeds 650 FSW. Deep water and temperature adversity is also forecast for the Alaska drilling areas.

While the majority of inland and harbor diving occurs at depths less than 100 FSW, the off-shore diver works with oil rigs which regularly require operations at depths reaching 380 FSW. It is not uncommon for dives to be required at 500–600 FSW. Exploration from mobile drilling units is beginning to take place in depths approaching and sometimes exceeding 1,000 FSW. More diving at these deeper depths can be anticipated.

The Department of Interior's provisional plan schedule anticipates that some 400 new platforms and up to 70 new underwater pipelines will be constructed in the near future. Paced by the rapidly expanding offshore petroleum and material extraction industry, the need for trained and experienced divers has and will become markedly increased. Divers are utilized in each of the three phases of this industry: exploration, development and production. During the initial exploration phase, each deep water rig utilizes between 5–10 divers, with the average using seven. One diving contractor has suggested that this expansion of off-shore activity alone will result, at a minimum, in the need for approximately 1,000 new divers (Tr. 151).

The configuration of the commercial diving industry is such that 90 percent of all off-shore operations are conducted by some 23 contractors who employ over half of the country's commercial divers. In addition, there are approximately 400 small and medium sized diving companies, whose work principally, but not exclusively, is confined to harbors and inland waterways. In much of the diving industry, the work is seasonal. All diving contractors, but especially the smaller ones, depend on part-time divers to fill temporary manpower needs.

With the projected increased demand for deep sea divers, concern has been raised as to the availability of adequately trained and experienced personnel to fill the existing and anticipated manpower void (see, e.g., Tr. 151–152). The previous training of divers being introduced into these operations, whether in the military, in shallow water diving, or in diving schools, is in many cases not well-suited to the more hazardous diving modes required.

Although, some diving contractors have developed an extensive training capability within their own organizations, most employers have not been able to do so. The result is that divers entering this field may not bring with them the necessary experience to be able to function safety. Similar factors may result in the entry into the field of new employers who do not possess sufficient relevant safety and health experience.

The diving industry, which is thus entering its most expansive stage of development, is in an area of employment devoid of mandatory occupational safety and health regulations, save for certain voluntary efforts by the industry itself. While the efforts, particularly as represented in the ADC diving manual, have had some measure of success and are to be complimented and encouraged, they do not have the force of law behind them, nor are they universally accepted. Efforts to establish a consensus standard have also not yet reached fruition. Thus, although diving is recognized by one of the nation's leading insurance carriers as an occupation with high-risk classification (Exh. 14), no enforceable set of national safety and health standards have, prior to this ETS, ever been established.

Work Practices and Hazards

Divers are called upon to utilize their skills in activities involving construction, repair, salvage, inspection, rescue and scientific exploration (see, e.g., Tr. 149).

The work environment of the driver is inherently a hostile one, posing a multiplicity of hazardous conditions. This situation with its inherent potentiality for high risk is being exacerbated by the increasing physical and mental demands resulting from the application of technological innovations.

Traditionally the diver has worked alone. Today, however, although many jobs still call for a single diver, a significantly growing number of assignments are requiring the use of diving teams employing backup and support specialists.

The diver must rely on an external life-support system while underwater, and must perform under a variety of highly specific performance constraints. These constraints include diminished sensory and perceptual capabilities, interference with cognitive processes and psychomotor skills, and reduced physical working capacity. Factors such as environmental, psychological, and/or physiological stress, inappropriate human engineering efforts, and inadequate selection and training further hamper the diver's efforts. The diver must make highly specific adaptations to his equipment, his environmental working conditions, the work strategies he uses to do the job, and the stresses which reduce his effectiveness (NIOSH I, 6–1).

In diving, several techniques and modes are available. These include self-contained (SCUBA), surface-supplied, bell, mixed-gas, and saturation diving. Their appropriateness for any particular situation depends on a number of factors, including the depth, time, and nature of the operation to be performed, as well as the experience and technical capabilities of the employer and his employees (see, e.g., Tr. 147; NIOSH I, 8–4, 5).

SCUBA diving, with the diver carrying his own air supply, is used primarily for inspections and search activities. Diver inwater mobility and quick operation setup are its principal assets. Breathing resistance, the diver's difficulty in physically orienting himself to the worksite, limited breathing gas supply and particularly the absence of clear voice communications with the surface limit the usefulness of SCUBA in commercial activities (e.g., NIOSH II, C–45–48).

Surface-supplied techniques, both helmet and mask, are commonly used throughout the diving industry (e.g., NIOSH II, C–48–52). This method involves providing the working diver with his breathing mixture, whether air or mixed gas, through a hose from a source located on the working platform surface. This is a reliable method of supplying the diver with life support and, because he is tethered to the surface, facilitates control over his activities below. The major safety limitation, however, involves the duration of inwater decompression; for while the diver is in the water undergoing decompression, he is continuously subjected to the temperatures, currents and other factors of the environment. A protracted stay induces fatigue and increases the likelihood of weather shifts which will affect surface operations (NIOSH II, C–6).

When a dive is particularly deep or lengthy, therefore, bell diving becomes appropriate (e.g., NIOSH II, C–52–55). An open bottom bell affords the diver environmental protection during decompression. Though it does not provide all the safety features of a closed transfer-under-pressure bell, it provides significant safety advantages when compared to the safety of a surface-supplied, inwater diver. Thus, with a bell the diver has a short umbilical, is always close to a sanctuary and can be decompressed in the safety of a deck chamber, and a dive can be readily aborted in the event of difficulty (NIOSH II, C–7).

Mixed-gas diving is carried out with mixtures of oxygen and inert gases such as helium, and/or nitrogen. This mode replaces air diving when the partial pressure of the oxygen and nitrogen in the compressed air pose the likelihood of

toxic effects. At present, mixed-gas diving is generally used from 150 to about 500 FSW. Generally, mixed-gas divers are hose-supplied and use semi-closed breathing. Diving may be done from bells or may be surface-supplied (Exh. 31, p. 2).

Mixed-gas diving can be divided into three categories: short duration, medium duration, and total saturation. Short duration profiles are used or minor repair, adjustment or inspection, and other typical diving support tasks. Working time is usually 15 to 30 minutes. This diving mode is characterized by relatively short decompression. Medium duration diving includes dives which generally last up to one hour or more, depending on depth, and may involve a long decompression time(NIOSH I, 2T-2).

The third category is total saturation diving, which is used in situations where the diver will be exposed to high pressures for long periods. For diving depths exceeding 400–500 FSW over two hours, saturation diving must be employed. The advantage of saturation diving is that once the body tissues become saturated at any given depth with all the inert gas they can absorb, the decompression penalty from this exposure remains the same regardless of the length of time endured at that ambient pressure (Exh. 31, p. 3).

Whatever the diving technique or mode used, the ability of diving and support teams to act effectively and safely is dependent upon the level of competence of each of its members. Ensuring that personnel meet the required qualifications and are in good physical condition is the responsibility of the employer, as no single aspect of diving safety is as important as the skill of the individual diver (see NIOSH II, B-1, et seq.). Improper actions by the diver can quickly lead to dangerous situations; panic in an emergency can mean death. The time between normality and emergency is often measured in seconds. The diver must be in excellent physical and emotional health to continuously and clearly perceive his own situation (NIOSH II, C-26).

In addition to well-trained personnel, sound operating procedures are necessary to ensure that diving operations are conducted in a safe and efficient manner (see NIOSH II, C-1 et. seq.). However, no single set of procedures can anticipate all operating situations. Sound judgment, an ability to recognize present or developing hazards, and maximum attention to personnel safety must continue to be the cornerstones of safe diving operations.

Underwater task assessment, determining what the diver must do to complete the job, is a basic element of effective planning (NIOSH II, C-2). Task assessment in diving is closely related to safety. If operations lack appropriate tools or materials for a given task, makeshift equipment or rigging which may endanger the diver may be used instead. Improper task evaluation may require an extension of bottom time, necessitating unplanned decompression or extending decompression time.

Environmental conditions often affect the choice of diving procedure and frequently determine whether diving can be carried out. Wave height and period, sea and air temperatures, weather conditions, underwater visibility and currents, and the nature of the bottom all have significant influence on diving safety. Although the exact conditions cannot be known until the operation begins, proper planning calls for attention to the selection of techniques and equipment which will yield maximum safety under anticipated conditions (NIOSH II, C-3).

Surface water conditions also govern whether diving may or may not be conducted safely. Surface water conditions can, within limits, be predicted and must be considered in planning the operation. Techniques and equipment can be selected to minimize hazards, if they are anticipated beforehand (NIOSH II, C-3).

Maintenance of diver warmth is a key step in planning. Anticipated temperatures must be evaluated, and appropriate passive or active thermal protection must be provided. High water temperatures can create situations which may expose the diver to heat prostration, while cold water operations cause rapid heat loss from the diver's body surface. This normally demands insulating suits of varying degrees of complexity, depending upon the thermal gradient. In deep diving when helium-oxygen is employed, heat loss is so great that it inhibits the body's ability to maintain normal body temperature. Such diving often requires suits equipped with supplementary heating (Exh. 6, 3–16, 17, 8–9; NIOSH II, C-3).

The type and quantity of equipment used is also critical to the conduct of a safe operation (NIOSH II, C-9; D-1, et seq.). All equipment used in diving operations must be in proper operating condition and thoroughly tested prior to use. The safety implications of equipment failure or misuse for the diver and possibly the surface crew are so severe that the greatest attention must be given to equipment condition (NIOSH II, C-28).

In addition to familiarity with his personal equipment, the diver must also be competent in using the tools he will employ and familiar with the tasks to be undertaken. This familiarity requires training and continuous practice to develop the required proficiency. The person in charge of the diving operation must ensure, before the dive is made, that the diver understands how the task is to be executed and its inherent dangers (NIOSH II, C-27). This is especially true because many of the work tasks performed by divers, such as cutting, welding, and using explosives, are themselves very hazardous.

It is important that the depth of the dive site be known with precision, by accurate measurement. Of even greater importance to safety is the continuous knowledge of the diver's depth on a real-time basis, because this will determine his decompression regimen (NIOSH II, C-10, 11).

An immediately available source of emergency breathing gas is a necessity in case a diver loses his primary supply. This reserve supply may take many forms, but proper administration of a diving operation requires that it be available to the working diver. In deep diving, methods of supplying additional gas to the diver to permit proper ascent in emergency situations must be carefully assessed. Diving bells, both open and closed, must be equipped with a reserve breathing gas supply. This will usually entail having a primary topside supply and a reserve cylinder supply on the bell for immediate switchover (NIOSH II, C-11, 12).

Communications of all forms are vital to safe diving. Whether to advise vessels in the area of the operation, summon emergency aid, or coordinate operations between the diver and the surface, good communications are essential and must be properly planned (NIOSH II, C-20).

Commercial divers work from a wide variety of surface platforms. These range from exploratory drilling ships and construction barges to offshore supply boats, tugs, bridges, tops of dams, and scaffoldings. A safe diving platform should be stable, secure, and have adequate working space. A proper platform is an important component of overall safety. For instance, the vessel should always be equipped with a diving platform, ladder, or stage for diver safety while entering and leaving the water. Also, all supplies, particularly compressed gas equipment, must be secured in a way which precludes their being dislodged by vessel motion. Emergency supplies that are stowed must be immediately accessible (NIOSH II, C-21–23).

Proper planning for emergencies and development of contingency plans is a requirement for all diving activities. Specific written instructions, which are understood and available to all members of the diving team, must be provided for all emergency situations (NIOSH II, C-23). Potential emergencies for which contingency planning is necessary include loss of voice communications, interruption of the surface gas supply, severance of the diver's umbilical (hose bundle), diver entanglement or entrapment, uncontrolled ascent to the surface (blowup), and an acute illness or injury to the diver while he is in the water (See, e.g., NIOSH II, C-49).

A standby diver is essential for most diving operations. His responsibility is to go to the aid of the working diver immediately. Dispatching the standby diver should not be delayed. At the first indication of working diver distress, the standby diver should be deployed. The order to reach the diver who needs help quickly (NIOSH II, C-23).

In an emergency many forms of outside aid may be required, and careful consideration must be given to this before the operation is undertaken. Necessary emergency information includes telephone numbers of recompression facilities, USCG, air transportation, closest hospital, and consulting physician trained in hyperbaric medicine. The remoteness of many diving sites places a

premium on effective first aid treatment in medical emergencies. Diving operations require that reasonably comprehensive medical supplies and first aid treatment instructions be available. At least one person trained in first-aid must be at every dive site (NIOSH II, C–24).

Knowledge of recompression treatment is essential in diving operations, particularly those involving dives requiring stage decompression. Situations can range from simple joint pain to life-threatening central nervous system (CNS) involvement and gas embolism. This contingency must be properly planned for. Required equipment, including a decompression chamber on site, is necessary where there is extended stage decompression and clear emergency instructions must be provided for every diving operation (NIOSH II, C–24).

Fire is a potential danger on diving platforms, especially in pressurized chambers or wherever compressed oxygen is being used.

Special precautions, such as monitoring the oxygen level in decompression chambers and eliminating combustibles to the extent feasible, need to be taken to protect against fire. In addition, emergency fire fighting and evacuation plans must be incorporated into the emergency procedures planning on every dive site (NIOSH II, C–33).

The quantity and quality of a diver's breathing gas are of fundamental importance to the diver's safety. The quality of compressed air should always be considered, as oil, carbon monoxide and carbon dioxide can be significant contaminants. Compressors should be well maintained and have impurity-free intakes. All premixed gases, even when tagged for composition, should be checked onsite for oxygen content before use to avoid errors which could produce anoxia or oxygen toxicity at depth. Similarly, use of compressed air from compressors requires a knowledge of the type and condition of the compressor to assure oil and carbon-monoxide-free breathing gas (NIOSH II, C–28, 29).

Location of the compressor intake is important. The intake must be situated so that it cannot draw in exhaust fumes, regardless of shifts in the prevailing wind. Also, the compressor intake should not draw from the vicinity of exhaust from the ship's engines or other operating machinery (NIOSH II, C–30).

Breathing gas must be available in sufficient quantity and pressure to permit normal and emergency operations to be conducted. Sufficient reserves must be available for all anticipated emergency circumstances. Backup sources must be available in case the primary source is lost (NIOSH II, C–19).

Hoses are a diver's life line, and their integrity must be protected to assure safety. All hoses comprising the diver's life support which are exposed to potential damage as a result of falling objects, personnel, traffic, etc., must be protected. All breathing gas hoses should be oxygen cleaned so as to purge them of contaminants which could otherwise react with the oxygen under pressure in the breathing mixture (NIOSH II, C–30).

Live boating, the practice of supporting a tethered diver from a vessel underway, is a technique often used to inspect newly laid pipelines and in other situations requiring diver mobility over long distances. This useful procedure has certain inherent hazards which require special consideration.

The propellers of vessels used for live boating must be equipped with shrouds or similar devices which will prevent the tether/umbilical from becoming entangled in the propellers. Clear, audible voice communications must exist between the diver and tender at all times during the operation. Tending a diver engaged in live boating requires special techniques and the tender must be familiar with such techniques (NIOSH II, C–37).

In the water, particularly in case of limited visibility, a number of underwater jobsite hazards may be present. Fouling by debris, structures, new and old rigging, rocks, and numerous other items is not uncommon. If the diver is fouled and indicates panic or is unable to free himself, the person in charge of the diving operation must immediately dispatch the standby diver to follow the working diver's lifeline and assist in freeing him. In situations involving entry into confined areas such as wrecks, tunnels, sewer outfalls or other situations in which entrapment is possible, a second diver must tend the primary diver at the point of entry (NIOSH II, C–40–41).

Divers have been killed working in the vicinity of major inflow/outflow pipes, sluices, etc., in which extremely high local currents may be encountered. If such conditions are anticipated, the employer must take special precautions to protect the divers from these hazards (NIOSH II, C–41).

Physiological Hazards

Divers are particularly, and in some cases uniquely, susceptible to certain kinds of physiological hazards. The nature of the employment requires divers to be exposed constantly to a hostile environment. On any dive, he must adapt to such potentially harmful physical agents as pressure, breathing mixtures, and water in addition to thermal exposure. One pervasive variable is the element of depth. Increased depth means increased pressure, approximately 1 atmosphere (14.7 pounds per square inch) for every 33 feet of depth. While every increase in pressure does not necessarily create a proportionately greater risk of a diver's encountering a physiological hazard, some medical hazards are inherently pressure-related.

When a person is exposed to a hyperbaric environment, the elevated gas pressure that he must breathe causes an increase in the quantity of gas dissolved in his body. Subsequent ascent to a lesser environmental pressure can cause this gas to come out of solution, and this can produce, either directly or indirectly, a condition called decompression sickness. As discussed more fully below, decompression sickness may be manifested as rash, pain, paralysis or even death. It can be prevented by controlling the ascent of the diver in such a way that the pressure of the gases in solution never exceeds some critical pressure, which is related to the ambient pressure. The plan or procedure for the regulation of an ascent in order to prevent the formation or growth of bubbles is called a decompression schedule or table. Many factors go into the determination of decompression schedule and its effectiveness in returning a diver to the surface safely (NIOSH II, E–1).

Gases enter or leave body tissues depending on whether their partial pressure in arterial blood is greater or less than their partial pressure in the tissues. The rate at which gases are taken up or eliminated by any tissue depends on the partial pressure gradient between the blood and tissue, the respective solubilities of the gas in blood and the tissue, the rate of blood flow through the tissue, and the diffusion rate and path of the gas within the tissue (NIOSH II, E–2).

The deeper the diving depth, the greater the initial gradient for gas uptake and the greater the maximum amount of gas which can be taken up. The longer an exposure, the closer each tissue will come to reaching equilibrium with the arterial gas consumption. Once equilibrium between the gas being breathed and tissue has been reached, however, no additional gas will be taken up even if the exposure is extended in time. This condition is called saturation (NIOSH II, E–3).

Bubbles will form in biologic systems only if gas micronuclei are present. Doppler ultrasonic monitoring has shown that some bubbles always exist during decompression, even in the absence of symptoms of decompression sickness, and have been identified as causing disturbances in the linings of the blood vessels and in the blood itself, and as the cause of long term, subtle physiological effects to various organs of the body (Tr., 260, 695–702; NIOSH I, 3–1–25; NIOSH II, E–5).

Bubbles are directly involved in causing the symptoms of decompression sickness. The term decompression sickness is applied to any group of signs or symptoms which result from a reduction in ambient pressure. The symptoms manifest themselves in a number of different ways: a critical bubble volume which can block a blood vessel or bend a nerve ending beyond its pain-provoking threshold; a blood-bubble interaction which can cause various forms of hematological disorder, and various autoimmune responses; or bubble-tissue interactions leading to extravascular biochemical abnormalities. The major categories of acute decompression sickness are: (1) Limb bends and cutaneous manifestations; (2) audio-vestibular disorder; (3) spinal cord involvement; (4) brain center involvement; and (5) chokes (NIOSH I, 7–4).

The symptoms may vary from mild local pain or itching of the skin to collapse with unconsciousness and sudden death. Decompression sickness usually causes symptoms shortly after a dive or other pressure exposure, or before reaching the surface from deeper dives (Tr., 45–46, Exh. 27; Exh. 28; Exh. 6, 8–11, 12, 13; NIOSH II, E–40).

One of the common terms used for decompression sickness is "bends". The term bends is accurately used for decompression sickness with "pain only" symptoms. Bends affect joints, and are characterized by a deep, steady pain which is not relieved by movement or changing the position of the limb (NIOSH II, E–40, 41).

Another common type of decompression sickness has cutaneous manifestations, i.e., only the skin is involved. There may be itching or burning sensation, and blotching or mottling of the skin. This is a relatively mild form of decompression sickness which is seen somewhat less frequently than local pain (NIOSH II, E–41).

Central nervous system (CNS) decompression sickness may take a number of different forms, varying from localized numbness, to paralysis, to collapse with unconsciousneses. The following signs and symptoms may indicate CNS involvement: numbness, weakness, pain in the abdominal region, unconsciousness, shock, visual disturbances, nausea and vomiting, speech difficulty, dizziness and lack of balance, among other abnormal sensations. Any CNS involvement is considered a seriout decompression sickness (NIOSH II, E–41).

Decompression sickness involving the audiovestibular system is seen more often during decompression from very deep dives. It may manifest itself as partial or total hearing loss or ringing of the ears—usually unilateral—or a sudden severe vertigo, dizziness and nausea (NIOSH II, E–41).

The word "chokes" is applied to a type of decompression sickness occurring when a diver experiences shortness of breath with coughing or wheezing, or may notice pain when taking a deep breath. The victim may suddenly lose consciousness and collapse NIOSH II, E–42).

As another result of exposure to a hyperbaric environment, divers as a class are subjected to an increased risk of sustaining skeletal damage. This condition, known as dysbaric osteonecrosis (also known as aseptic bone necrosis, avascular necrosis, or commonly as "bone rot"), is the result of gas absorption into and release from tissue which cause, in varying degrees, a deadening of the bone and marrow. Although the disease was initially recognized in 1911, it was not until 1941 that it was identified in divers, and only recently have its pathogenesis and etiology been significantly explored. In its earliest stages, dysbaric osteonecrosis appears as lesions in the shafts of the long bones. Increased risk of additional lesions are likely to occur with extended diving experience. If the lesion is situated near a joint, a structural failure may occur. Such failure will result in pain and limitation of movement, followed by the development of degenerative arthritis. A juxta-articular lesion can be a sufficient joint disorder to require that diving be discontinued for those found to have such a condition. While the use of physiologically tested decompression tables will not eliminate skeletal damage entirely, such tables are likely to reduce its incidence. Data suggests an extremely high incidence where there has been an absence of proper diving protocols. Studies also suggest several apparent predisposing factors, helpful in identifying those divers with the greatest susceptibility or highest risk of developing osteonecrosis. They include: (1) obesity, (2) age, (3) prior decompression sickness, and (4) number, depth, and duration of dives (Tr., 64–70, 86–98, 461–64; Ex. 2; Ex. 28; NIOSH I, 2–1–17; NIOSH II, E–42).

Other medical problems which are not true decompression sickness can occur as a result of reduction of ambient pressure. The most prominent of these is gas embolism, usually caused by overexpansion of the lung when a diver holds his breath while ascending. Gas thus forced into the bloodstream will continue to expand as the ascent continues. If any gas bubbles become too large to pass through the blood vessels, an obstruction or embolus will form and block the proper flow of blood. The bubbles of air forced into the bloodstream may be carried directly to the brain; they may lodge in the arteries or the spinal cord; or they may flow under the skin and collect around the heart or in the chest causing collapse of a lung. This condition can rapidly cause dramatic and very serious symptoms—weakness, disorientation, visual and hearing disturbances, vertigo, nausea, shock and unconsciousness (Tr. 46; Exh. 6–3–23, 8–9; NIOSH II, E–43).

Related problems arise due to gas being forced into other body spaces. Pneumothorax occurs if the membrane lining the outside of the lungs ruptures, causing gas to escape from the lung into the chest cavity and the lung to collapse. Another condition sometimes associated with decompression is mediastinal emphysema, which is the result of air being forced into the tissues around the heart and the major blood vessels. During decompression, the air trapped here may rapidly expand, causing circulation stress, pain, and shortness of breath (Exh. 6, 8–9, 10; NIOSH II, E–43).

Other pressure-related problems may arise as a diver descends in the water whenever the pressure in the natural air passages of the body (lungs, ear and sinuses, teeth, and intestines), or in certain items of equipment which put an air space next to the diver's body or face, cannot be equalized due to blockages which trap air in the passages. This situation is known as barotrauma (or a "squeeze") and can be painful. If the pressure imbalance is great enough, it can result in ruptured blood vessels or other tissue damage (Exh. 6, 3–18–20).

Barotrauma can affect the middle ear, external ear, teeth, lungs, intestines, face, or whole body (Exh. 6, 8–7). The most frequently occuring otologic problem associated with diving is aural barotrauma, resulting from a pressure differential between the middle ear and external environment. During ascent or descent, alternobaric vertigo may occur as a result of unequal middle ear pressure equalization. An upsurge in persistent and permanent cochlear and vestibular injuries associated with various phase of diving have also been reported. One type has involved several cases of round window fistulas in which severe neurosensory hearing loss and tinnitus have been experienced. A second type of inner ear injury has been traced to exposure to extended deep dives in which breathing mixture composition changes were involved (NIOSH I, 1–3–8).

With the recent advent of more frequent and deeper exposures, such as occur in saturation diving, in combination with the use of different inert gases, increased instances of ear squeezes involving auditory and vestibular dysfunction have occurred resulting in vertigo and hearing loss. Divers cannot perform sophisticated underwater operations if their auditory-communication and vestibular-orientation systems are malfunctioning. In the diving environment, the otolithic system which conveys information about linear motion and direction of gravity may become distorted causing critical confusion as to upward and downward directions (NIOSH I, 1–1).

A further compression-related physiological hazard is the High Pressure Nervous Syndrome (HPNS). This is a condition due to too much compression at depths greater than 500 feet causing changes in the electrical activity of the brain, tremors, fatigue, nausea, and dizziness. Its onset makes effective work difficult at these depths and may set the limit for man in deep diving. It indicates the need for compression profiles or tables at the depths where High Pressure Nervous Syndrome has been observed (Tr. 263–4; NIOSH I, 1–5, 12–1 et seq.).

In addition to the hazards caused, directly or indirectly, by the high pressure to which a diver is exposed, he is also exposed to a number of hazards which are associated with his breathing mixture.

The fact that a diver breathes a compressed mixture, whether air or a mixture of gases (O_2-N, O_2-He, or O_2N-He, usually) below approximately 190 feet, and is dependent upon special equipment (the compressor and gas cylinders, helmet or mask, and hose) to bring the breathing mixture to him, poses certain physical risks for him. The diver's life is directly dependent upon the quantity and quality of his breathing mixtures. Any deviation from prescribed procedures can result in a number of serious respiratory problems. In very deep diving, the margin of error is very narrow. When one is dealing with a special mix, a change of a quarter of one percent of oxygen in the

mix may be the difference between death by asphyxiation or survival. Because of the particular nature of the underwater environment, any problem with the breathing mixture is potentially very grave (Tr. 38–39, 46; Ex. 6–8–5).

While underwater, a diver must breathe air or other gases at the pressure of the water surrounding him. Oxygen must be in all breathing mixtures, but it becomes toxic when the partial pressure in the mixture exceeds certain limits and must therefore be diluted with an inert gas. Nitrogen is an appropriate diluent for shallow dives, and helium has proved adequate for deeper dives. However, alternatives do exist. Neon and hydrogen are the most likely alternatives to helium and nitrogen. Several factors influence their respective usages including cost, availability, storage, efficiency and physiological side effects. Nitrogen could be used safely at depths in the range of less than 150–200 FSW. At 150 FSW most divers experience the beginnings of nitrogen narcosis, which can cause enough deterioration in memory and mental capacity to be an operational problem, and impair judgment enough to be a serious safety factor. In addition, nitrogen is highly soluble in body fluids, making it difficult to remove safely during decompression. Furthermore, its density makes it difficult to breathe at increased pressures. Helium on the other hand is light, easy to breathe, has a low solubility and is not narcotic. However, it does have three drawbacks especially as depths approach those of the outer continental shelf: distortion of voice communication (at 400–600 FSW); considerable heat loss as a result of its high thermal conductivity; and a tendency to produce hyperexcitability of the nervous system in conjunction with rapid decompression (HPNS). Safe alternative practices are available such as nitrogen saturation, excursion diving from shallow habitats, helium adjustment, employing speech unscramblers, adding a heat capability to equipment, slowing the rate of compression, or using trimex (helium, oxygen and nitrogen). Neon has successfully been substituted for helium under controlled conditions for dives as deep as 640 FSW; and hydrogen may be used after taking proper precautions with respect to flammability and explosive hazards. Another practice involves multigas mixtures and gas sequencing. Several benefits accrue from this practice: reduced costs, improved decompression, reduced chilling, improved voice communication, and lessening of the effects of HPNS. However, the practice is also suspected under certain conditions of producing vestibular decompression, skin lesions and itching (NIOSH I, 8–1 et seq.).

The characteristic dangers of breathing under water are: oxygen deficiency, oxygen poisoning, nitrogen narcosis, and chemical irritants. The following disorders all result in a shortage of oxygen reaching the cells for normal metabolism.

(1) *Hypoxia,* which is any situation in which the tissue cells fail to receive or utilize enough oxygen due to a loss or inadequacy of the air supply. It can be caused by a number of factors, including lack of adequate oxygen in the breathing mixture. Depending on the severity of the condition, symptoms include drowsiness, inability to think clearly, lack of fine-muscle control, discomfort, rapid breathing, and unconsciousness (Ex. 6, 3–14, 8–6).

(2) *Carbon dioxide poisoning (hypercapnia),* which is a build-up of carbon dioxide in the breathing supply or in the body as a result of inadequate ventilation; failure of carbon dioxide removal equipment (as in a closed or semiclosed SCUBA); increased carbon dioxide production during work or while under stress; controlled or "skip" breathing; excessive dead space in the equipment; or contamination of the breathing mixture with carbon monoxide. The most common source of hypercapnia is the diver's own metabolic processes, and the most common cause is the failure to properly ventilate the breathing apparatus. The symptoms include confusion, inability to think clearly, unconsciousness and convulsions. Breathing an excess of carbon dioxide may increase the possibility of decompression sickness, and will speed the onset of oxygen poisoning (Ex. 6, 3–15; NIOSH I, 9–3).

(3) *Asphyxia,* which is simultaneous hypoxia and hypercapnia. Hypoxia and hypercapnia do not always occur together; however, when hypoxia becomes severe enough to halt breathing, carbon dioxide rapidly builds up in the body resulting in asphyxia (Ex. 6, 3-15).

(4) *Carbon monoxide poisoning,* which is caused by induction of exhaust fumes into the air supply compressor. Carbon monoxide is highly toxic because it combines with hemoglobin 200 times more readily than does oxygen, displacing large quantities of oxygen and rapidly bringing about hypoxia. The symptoms are almost identical with those of hypoxia (Ex. 6, 3–16; NIOSH, 9–10).

An excess of oxygen can be a problem as well as the lack thereof. Partial pressures of oxygen in excess of that encountered at normal atmospheric conditions may be toxic to the body, depending on both the partial pressure and the exposure time. From approximately 0.6 to 1.6 atm O_2, with exposure times varying from days to hours, lung toxicity may occur which is first manifested as lung irritation and can lead to lung tissue damage if the exposure is continued. Above partial pressures of 1.6 atm O_2, central nervous system oxygen toxicity occurs. Established depth and bottom time limits normally preclude the possibility of the development of inwater oxygen toxicity in air diving. It may be encountered while administering 100% oxygen during surface decompression procedures or recompression treatment if the diver is not constantly monitored inside the chamber for the related symptoms of oxygen toxicity. It is also a potential problem for divers breathing mixed gas below approximately 190 feet. The symptoms most often encountered, in the approximate order of their likelihood of appearance, are muscular twitching, nausea, dizziness, tunnel vision, abnormal hearing, breathing difficulty, anxiety and confusion, unusual fatigue, incoordination, and convulsions (Ex. 6, 3–20, 8–6; NIOSH I, 9–2; 10–3–5; NIOSH II, E–7–9).

Similarly, an excess of nitrogen can produce toxic effects. High partial pressures of nitrogen in the breathing mixture produce nitrogen narcosis. There is a wide variance in susceptibility to it among individuals, but its symptoms can begin to be experienced below 100 feet and are particularly prevalent below 150 feet in air diving. The narcosis is characterized by a slowing of mental activity, fixation of ideas, slowing of reaction time and a general euphoria. The greatest hazard of nitrogen narcosis is that it may cause the diver to disregard the job or particularly his personal safety (Ex. 6, 3–20, 8–6; NIOSH I 8–7, 9–8, 9).

The presence of irritating chemicals contaminating the breathing mixture can result in pulmonary edema. For instance, oxides of nitrogen from diesel engine exhaust can cause serious lung damage; likewise, oil from a compressor can cause a serious problem if it gets into the breathing mixture (Tr. 47, 596–600; Ex. 48; Ex. 6, 8–6; NIOSH I, 9–10–13).

Finally, there are hazards associated with the water itself as a work environment. Drowning is a risk faced by anyone who goes into the water. A diver, like a swimmer, can fall victim to overexertion, panic, inability to cope with rough water, or the effects of cold water or heat loss. Divers wearing lightweight or SCUBA gear can drown if they lose or ditch their mask or mouthpiece. This could be the direct result of failure of the air supply, or of panic in a hazardous situation. Drowning with deep-sea gear is rare. It can happen, however, if the helmet is not properly secured and comes off, or if the diver is trapped in a head-down position with the spit cock open, his chin pressing on the chin button, or his suit torn. According to the U.S. Navy Diving Manual, the prevention of drowning is best achieved by the establishment of safe diving practices and the careful selection of diving personnel (Ex. 6, 8–7).

A diver is often called upon to perform difficult work tasks under extreme circumstances. Much of the work involves heavy construction in deep water, work which often involves the manipulation of large and heavy objects at depths and in diving conditions which are bordering on the limits of technology. The normal hazards of such work are compounded by the fact that the diver is working on a vessel or in the sea, dressed in cumbersome gear, limited in his mobility and visibility, and sometimes restricted to a confined space. The risk of serious trauma is therefore always present, and injuires, such as severe crushing, amputation, head injuries, compound fractures and burns must be anticipated and protected against.

Chronic fatigue and deterioration has also been identified as a particular problem for divers working under stress in the saturation mode, where they may

be under pressure for twenty or more days (Tr. 36).

Additionally, any medical emergency, such as appendicitis or heart attack, becomes most serious when it occurs to a diver when in the water under pressure, particularly to those in a saturation mode where the decompression from the pressures experienced at saturation may take as long as a week. There is accordingly a need for careful planning concerning how to respond to such emergencies.

SUMMARY AND EXPLANATION OF THE STANDARD

The standard is divided into five substantive portions: General; Personnel Requirements; Operational Procedures; Diving Equipment and Systems; and Recordkeeping Requirements. Thus, to a considerable extent, it follows the format established by the ANSI Z–135 draft and the ADC Manual.

A. GENERAL

The standard applies to diving and related operations and activities associated with all employments covered by the Act including general industry, construction, maritime, shipbuilding, shipbreaking, ship repairing, and longshoring. Included in this coverage is diving engaged in for educational, scientific and research purposes, as well as diving engaged in by underwater instructors. Of course, diving by persons engaged in recreational or sport diving or other diving not in an employment context are beyond the jurisdiction of the Act. In addition, agencies of the United States, individual states and their political subdivisions, including state educational institutions, are not included in the definition of "employer" under section 3(5) of the Act and therefore are not subject to OSHA jurisdiction.

The standard does not apply insofar as another Federal agency exercises statutory authority to prescribe or enforce regulations affecting occupational safety and health.

Accordingly, the standard applies to every place of employment within OSHA territorial jurisdiction where diving operations are carried out. That is, it applies to all work operations carried out for an employer in which a type of diving such as SCUBA, surface-supplied, mixed gas, bell or saturation diving is performed.

While an issue was raised at the hearing as to the appropriateness of including scientific and educational divers and underwater instructors in such a standard, the Assistant Secretary concluded that, despite certain differences in operational techniques and modes among the various classes of divers, the commonality of the underwater environment and attendant similarity of work-related hazards called for uniform treatment and inclusion for purposes of the ETS. For example, requirements for medical examinations, training, and emergency procedures are deemed essential to safe work practices regardless of the nature of the employer's operations.

Although the scope of this standard is broad, covering every diving operation, the specific provisions of the proposed standard that will apply to any particular employer depend in certain respects upon the nature of the diving operation that is planned. Thus, for instance, certain requirements are limited to stage decompression diving only. Others apply only to SCUBA diving, and so on. In that way, the standard avoids placing unnecessary requirements on employers where they are inappropriate in view of the nature of their operations.

Pursuant to the statutory framework, the responsibility for compliance with the requirements of the ETS is placed upon the affected employers. In general, employers engaged in diving operations are required to do the following:

(a) Employ competent employees;

(b) Have and maintain a safe practices manual;

(c) Follow safe and healthful work procedures;

(d) Use appropriate tools, equipment, and systems; and

(e) Record and report job-related fatalities and serious illnesses, injuries, and accidents.

Each of these general responsibilities is elaborated upon in the substantive sections of the standard.

B. PERSONNEL REQUIREMENTS

OSHA believes that the safety and health of divers depend in large part upon their own competence and physical fitness. The standard place the responsibility on the employer to assure that his divers and surface support personnel are both competent and physically fit to perform their assigned tasks in a safe and healthful manner.

The concept of competence within the meaning of the standard includes proficiency with every aspect of a task to which a diver is assigned, to be acquired through appropriate training or equivalent experience, so that it may be performed safely. Where an employee lacks such competence in any necessary area, the employer must require the employee to take appropriate training, or he must assign another employee who possesses the necessary competence.

An essential element of employee competence for a diver is the diver's ability to meet the required physical qualifications of the standard. These basic physical qualifications must be determined on the basis of a physical examination (with a re-examination required after certain prescribed injuries or illnesses). To that end, the standard requires every employer to make available at his cost the services of a licensed physician to perform medical examinations designed to ascertain the employee's fitness to perform his assigned tasks.

The standard provides a table of tests to be administered by the examining physician at the initial examination (Table I), dependent in part on the nature of the diving engaged in. At the same time, there is a provision whereby a physician can utilize alternative medical tests or procedures if he can demonstrate that they are at least equally effective in establishing the diver's medical qualifications. Morever, certain physical conditions which are deemed totally inconsistent with safe and healthful diving are designated as disqualifying conditions.

While the responsibility necessarily lies with the employer to determine whether an employee is likely materially to impair his health by continued diving and therefore should be withdrawn or appropriately limited in his diving activities, he must make this determination on the basis of the examining physician's written report to him. The standard prescribes that the examining physician's written report indicate the results of the tests given in the medical examination as well as offer an opinion as to the effects of diving on various of the diver's vital systems, i.e., pulmonary, muscular, cardiac, skeletal, and nervous systems; on the ability of his gas-containing organs for effective external communications; and on the likelihood of aggravating existing evidence of bone necrosis. The physician must also offer an opinion as to the existence of any of the enumerated disqualifying conditions and recommend any limitations upon the employee's activities as a diver.

This physician's report, which must not include information extraneous to the employee's physical qualifications as a diver, must be given to the employer with a copy provided to the employee. The employee also has the right to examine any other materials in his medical record and may request the transfer of his record or a copy thereof to another physician or employer.

The employer is required to keep the physician's written reports and a copy of the information he provided the physician as the medical record of each affected employee for at least five years.

C. OPERATIONS PROCEDURES

The operations procedures sections of the standard establish basic procedures which must be followed when engaging in diving operations. A large portion of the emphasis within the applicable sections is placed upon proper planning and effective communication between the employer and his employees of the procedures to be followed in carrying out a particular diving operation. They also set forth certain requirements which must be included within a planned diving operation depending on the type of diving operation that is being carried out. These are intended to be minimum requirements of general applicability and no inference should be drawn that items omitted from this standard, which in particular situations are necessary for safe and healthful diving operations, need not be followed. As elsewhere, the responsibility for assuring that these operational requirements are met is placed upon the employer.

The first requirement which an employer must meet is to develop, maintain,

and comply with a safe practices manual. It is expected that this manual, which is to be made available to each employee, will comprehensively present the safety and health practices required in the areas of work assignments, operations to be followed, and equipment to be used, for each type of diving operation that an employer engages in. It must also include a description of the procedures to be followed in the case of certain specified emergencies.

This manual must include at a minimum the requirements of this standard, and, in addition, must indicate whatever other safe practices the employer requires in the carrying out of particular diving operations. These too should be equally directed, as the requirements of this standard, towards ensuring the safety and health of the employees. Existing manuals may be used to meet this requirement of maintaining a safe practices manual to the extent that they meet the specific provisions of the standard and to the extent that they are actually followed in the carrying out of an employer's diving operations.

The standard anticipates that the safe practices manual will not be sufficient for all occasions. It therefore provides that, prior to commencing a diving operation, the employees must be instructed in the details of the dive to be performed. For situations not included in the manual, instructions must be given to the affected employees in how to conduct the operation safely. Although circumstances may not always make it feasible to provide these instructions in writing, this must be done whenever there is sufficient time to do so.

Employees should be familiar with the requirements of both the manual and any operational diving plan which affects them. Immediately before any operation, the employer must ensure that the diver inspects his personal equipment and tools. Similarly, the employer and affected employees must consult together whenever there are hazardous activities or conditions in the vicinity which would threaten the safety of the operation or the health of the employees so that the employer may decide whether to suspend the operation temporarily. In any event, the employer must not require a diver to dive against his will.

Prior to the commencement of any diving operations, several requirements must be met. A list of available sources of emergency aid, equipment and professional assistance, and instructions for establishing contact with them in case of emergency, must be available at the worksite as well as at any field operations office or principal place of business. Two-way communications necessary to the requisition of such emergency aid must be available or accessible to the worksite.

There must also be first-aid supplies at the worksite, and at least one employee on site must be trained in first-aid.

Two of the most important general operational requirements involve the use of decompression chambers and decompression protocols. The standard requires that a decompression chamber be present at the worksite for all dives requiring stage decompression in excess of 30 minutes. One of the most difficult, and hence hazardous, periods for a diver is the required time spent for physiological adjustment as a result of exposure to water pressures. During this decompression or recompression period the diver's body is subjected to extremely stressful conditions which are capable of producing a variety of diseases or illnesses. Several factors increase the risk of danger: the deeper the dive (i.e., the greater the water pressure), the more exotic the breathing mixture; the longer the bottom time (duration of the dive), the more severe the exposure; and the increased frequency (repeated number) of dives over a short period, the lessening of the diver's ability to tolerate pressure exposure. All of these components prolong the period needed for decompression, and the longer the decompression period the greater the likelihood of a hazard-inducing occurrence.

When the decompression period takes placed in the water (at staged depth intervals) the serious risks attendant to decompression, per se, are heightened because of the potential trauma and uncertainty associated with prolonged underwater exposure. Isolation and inability to render immediate medical treatment aggravates the diver's already high risk situation. To lessen these risks, the standard requires the presence of a decompression chamber for dives in which stage decompression in excess of 30 minutes is involved. These chambers provide a controlled environment for physiological adjustments to the decompression process. They remove the diver from underwater exposure hazards, and allow immediate accessibility in the event of medical or other exigency. They can be used in an emergency as a hyperbaric treatment facility, including for the recompression of divers who exhibit symptoms of decompression sickness.

Although the presence of an onsite decompression chamber is optimally desirable whenever stage decompression is required, the evidence suggests that the highest risk of decompression-related hazards occurs when prolonged periods of decompression are anticipated. These usually occur at the deeper depths where the likelihood of remoteness and isolation are great.

Most shallow water diving occurs in inland waters and harbor areas. Inasmuch as the transportation and medical facilities are often in proximity of shallow diving operation sites, the standard allows dives with decompression times of less than 30 minutes to be performed without the presence of an onsite decompression chamber. This would permit dives of relatively long duration at shallow depths, and some deeper dives with short bottom times using only in-water decompression procedures.

Of course, any employer who plans stage decompression dives, whether or not in excess of 30 minutes decompression time, must include the location of a decompression chamber and medical facilities in the list of emergency aid to be available at the dive site. In the event of a medical or other emergency a diver could thus be transported and treated promptly at a nearby medical facility.

With respect to decompression protocols, including tables, the standard requires that appropriate tables devised in accordance with tested physiological criteria be available at the dive site and adhered to. In so requiring that decompression tables and schedules be devised in accordance with tested physiological criteria, the standard embodies, in general terms, the current state of the art (See, generally, NIOSH I, 2T–1 et seq.). Adherence to tables devised in accordance with sound physiological principles is likely to produce a minimum of adverse symptoms while undergoing the necessary decompression or recompression so essential to the well-being of the diver.

Because of the many variables involved and the extensive theoretical and experimental research that is still needed, adoption of a single set of tables (e.g., those of the U.S. Navy) was deemed inappropriate for inclusion within an OSHA standard at this time. Furthermore, evidence in the record suggested the inherent inapplicability of military diving tables for commercial purposes (e.g., Tr., 169–70, 457). As more information and research data on diving tables becomes available, OSHA anticipates that a more sophisticated and detailed protocol will be developed for incorporation into a subsequent diving standard.

Other general operational requirements include the following:

(1) Inspection of tools, equipment, and systems to ensure that they are in proper working condition prior to and throughout an operation;

(2) A safe means of entering and leaving the water;

(3) Special precautions for adverse thermal exposures;

(4) A standby diver ready to reach a diver within five (5) minutes for all dives below 100 FSW, or which are unusually hazardous; and at the point of entry of any restricted area in which a diver is working;

(5) Special precautions when diving near underwater suction hazards;

(6) The use of specified warning signals;

(7) A reserve breathing gas supply sufficient for life support until the diver can safely be returned to a refuge or the surface whenever a dive involves stage decompression;

(8) An operable, two-way audio communication system between the diver and the surface (tender); and

(9) A sharp knife to be carried on every dive.

Each of these general operational requirements is necessary to protect employees engaged in diving from the grave danger to which they are exposed.

There is one other requirement relating to general operations procedures. The employer is obligated to record cer-

tain information pertaining to each diving exposure to which a diver is subjected. This record includes such vital information as depth, bottom time, and decompression schedule used. This record is considered essential to the safety of diving operations in that it acts as a check upon departures from the dive plan and provides a body of data which allows for the pinpointing of problems which may have arisen in the course of the operation and on the basis of which improvements can be made in future operations. A separate record must be made for each diver with a unique exposure. Such records must be kept for five (5) years.

In addition to the general operations procedures, the standard requires certain procedures considered necessary for inclusion in an ETS, which are specific to different modes and types of diving. These practices concern self-contained diving, surface-supplied diving, saturation diving, mixed-gas diving, bell diving, and live-boating respectively.

For self-contained diving (SCUBA), the standard allows for the use of a buddy diver or a safety line operated with pull signals in lieu of the general two-way audio communications requirement between the diver and the surface. It requires that the planned time, including decompression time, of a SCUBA dive not exceed the air supply duration of the cylinders (disregarding the emergency supply). Moreover, it requires that the cylinder pressure be determined immediately before each dive.

For surface-supplied diving, the standard requires the employer to assign a sufficient number of employees to ensure the diver's safety and health and to make possible effective response in case of emergency. Also, it establishes that the depth of each dive be determined prior to its commencement.

For saturation diving, the basic specific requirement is that the employer develop and include in the safe practices manual an evacuation plan to be put into effect in case it should become necessary to rescue or retrieve a manned HOPV in an emergency.

In regard to mixed-gas diving, the standard sets the basic requirement that the breathing mixture be composed of a physiologically appropriate mixture of gases, taking into account the depth and duration of the dive. Specifically, it sets a limit of 220 FSW as the depth below which air shall not be used as the breathing mixture, and it provides that the use of air between 190 FSW and 220 FSW be limited to dives not exceeding 10 minutes in bottom time. This is in recognition of the fact that air dives have been conducted safely in such operations as pipeline laying down to 220 FSW under that time limitation, notwithstanding the fact that 190 FSW has long been recognized in the U.S. Navy Air Tables and elsewhere as the outer safety limit for longer duration air diving.

For bell diving, a minimum of two divers must be used for all dives involving a closed bell. The standard requires that either a closed or open bell must be used whenever a dive exceeds 220 FSW or 120 minutes decompression time. Below 300 FSW, only a closed bell must be used. These limits were chosen because of evidence in the record that bells are advisable when there is mixed gas diving and that the absence of bells in circumstances where this standard would require their use have unnecessarily placed divers in peril with sometimes tragic results (Tr. 316, 544, 546, 550–53, 591–92, 595–96; 617; Exh. 47). Compliance with the bell requirements are deemed essential to diver safety.

The purpose of this requirement is to provide a place of refuge for a diver whose work takes him to severe depths or requires a lengthy decompression and to allow for the raising of a diver in trouble to the surface under pressure. A wide range of bells, from relatively simple underwater shelters to highly sophisticated habitat-type systems, exist which satisfy this requirement.

The standard also concerns itself with potential bell diving emergencies by requiring the availability of adequate means of rescuing a bell in distress. A standby diver must be on site to attend a distressed bell at the surface.

Finally, for liveboating, there is a requirement that a protective device be installed around the propeller while the boat is underway; that divers engaged in live-boating operations carry a reserve breathing gas supply (bailout bottles) with them; and that a standby diver be available for all such operations.

Diving Equipment and Systems

In the sections concerning diving equipment and systems, the standard establishes certain basic hardware requirements which are deemed essential to diver safety and health. It also provides for the periodic testing of certain equipment, and the recording of the results of such testing, to ensure that the equipment remains in proper working order throughout the diving operations. As elsewhere, the employer is responsible for ensuring that the requirements of these sections are met.

Specifically, the equipment and systems covered are:

1. Helmets and masks;
2. Dry suits;
3. Gas supply hoses;
4. Air compressors and systems for respirable air;
5. Human occupancy pressure vessels (HOPV's);
6. Depth gauges; and
7. Compressed gas equipment.

Helmets and masks (other than oral-nasal) must be capable of ventilating at least 4.5 cubic feet per minute (cfm) when supplied at the manufacturer's recommended pressure. They must be equipped with a two-way audio-communication system (unless used for SCUBA). Surface-supplied masks and helmets must have non-return valves. When appropriate, the material they are made out of must be resistant to salt-water corrosion.

Dry suits (or similar buoyancy changing equipment) must be equipped with exhaust valves to minimize the possibility of blowup.

Gas supply hoses must be rated for a bursting pressure at least 4 times greater than maximum working pressure, and a working pressure no less than the maximum pressure exposure plus 100 pounds per square inch (psi). They must be marked at prescribed intervals, kink resistant, and capable of the required flow rates for the system used. They must be tested at least annually to twice the maximum working pressure. Hose fittings must be salt-water resistant, where appropriate, and of a kind that cannot be accidently disengaged. When not in use, the hoses must be protected from the possibility of foreign matter entering into them. When necessary, they should also be cleaned so as to remove contaminants which could otherwise react with oxygen under pressure. The hoses and fittings used in oxygen service must be tagged or otherwise marked for identification.

Volume tanks used in compressed air systems must comply with the American Society of Mechanical Engineers (ASME) Code for Boiler and Pressure Vessels, Section VIII, Unfired Pressure Vessels, and, where applicable, must be approved by the Coast Guard. In addition, they must be equipped with a check valve on their inlet side, a pressure gauge, and a relief valve so as to prevent excessive pressure buildup. All air compressor intakes must be located in an area free of contamination or piped externally to a contamination-free area. The standard also establishes certain air purity requirements for respirable air to the diver.

Similarly, all HOPV's must conform to the requirements of the same ASME Code, and, where applicable, satisfy Coast Guard approval procedures. Hard piping systems, fittings and tubings carrying pure, high pressure oxygen must be of corrosion resistant metals. HOPV internal oxygen outlets must have nonreturn or shut-off valves. Shut-off valves used in oxygen systems above 125 psi must be slow-opening. A means must be provided to prevent the oxygen concentration from rising above 25 percent of the atmospheric content, and the possibility of continuous monitoring of the oxygen concentrations while the HOPV is in use must be established. Combustibles must be eliminated to the extent feasible through proper design and outfitting. There must be the possibility of maintaining continuous visual observation of persons in the HOPV from the exterior. An anti-suction device must be installed inside the HOPV on the exhaust outlet. There must also be two-way audio-communication while the HOPV is in use.

Depth gauges must be deadweight tested or calibrated against a master-reference at least every six months; and cards or labels to that affect must be attached to the gauges. The depth gauges must be installed so as to allow a system check of their accuracy.

Compressed gas equipment, such as cylinders, must be stored in a well ven-

tilated area and protected from heat or falling. They must have protection caps over the necks and valves when not in use. Oxygen systems must employ oxygen compatible pressure regulators to control flow.

To keep track of his equipment and its testing, the employer is required to maintain an equipment log. The log must contain information concerning the testing of gas supply hoses and fittings, the procedures followed in the oxygen cleaning of hoses, the maintenance and repairs to the air compressor and air system, and the testing and calibration of gauges. Entries into the log must identify the equipment or part, the nature of the work, the date of the work, and the person performing the work. This log must be kept at least five (5) years.

Recordkeeping Requirements

Employers engaged in diving, like all employers, must comply with the basic OSHA requirements for the recording and reporting of occupational injuries and illnesses which are contained in 29 CFR Part 1904. In addition to the reporting of all occupationally related fatalities and of hospitalizations of five or more employees, which is required by that regulation, the diving standard requires employers to report to OSHA all occurrences necessitating a medical reexamination under the standard, i.e., all decompression sicknesses with vestibular or central nervous system dysfunction, and all illnesses or injuries requiring hospitalization of 72 hours or more, or requiring medical treatment by an attending physician for five or more days.

Finally, any manual, written instruction, record, or log required to be kept by the standard must be made available for inspection and copying to an authorized representative of OSHA upon request.

Inflation and Environmental Impact

Pursuant to section 5(b)(8) of Secretary's Order 15–75 (40 FR 227, November 24, 1975), which pertains to standards issued under section 6(c) of the Act, notice is hereby given that an inflation impact analysis will be prepared and made available prior to the promulgation of any permanent standard resulting from this Emergency Temporary Standard.

The National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.) and regulations issued thereunder (29 CFR Part 1999) require that Federal agencies assess their proposed major actions to determine whether a significant impact on the quality of the human environment may result, and if necessary to prepare an environmental impact statement. It has been determined that, at this point, the issuance of this occupational safety and health standard is not a major Federal action significantly affecting the quality of human environment, and that an environmental impact statement is therefore not necessary.

Public Participation

This emergency temporary standard shall serve as a proposed rule in the rulemaking proceeding being commenced under section 6(b) of the Act. Additional proposals concerning this matter will soon be published. At the time of such publication, all interested persons will be invited to submit written data, views and arguments concerning this standard and the additional proposals, including comments on inflationary and environmental impacts. Interested persons will also be invited to file objections and to request a hearing on the proposals.

Anyone wishing to comment at this time may do so by submitting such comments in quadruplicate to the Docket Officer, Docket No. H–103, Occupational Safety and Health Administration, U.S. Department of Labor, Room N–3620, 3rd and Constitution Avenue, NW., Washington, D.C. 20210 (telephone: 202/523–8076). All comments will be available for public inspection and copying at the above address, will be part of the record of this proceeding, and will not have to be resubmitted at a later date.

List of References

A. Transcript of Informal Fact-Finding Hearing on Diving, Nov. 11–14, 1975 (4 vol.).

B. Hearing Exhibits:

1. United Brotherhood of Carpenters and Joiners of America, AFL–CIO, Petition submitted 8/14/75.

2. NIOSH Symposium on Dysbarism-Related Osteonecrosis.

3. Proposed American National Standard on Diver Safety of the American National Standards Institute, Final Draft of ANSI Z–135 Committee.

4. Manual on Safe Practices in Commercial Diving Operations (Association of Diving Contractors).

5. National Oceanic and Atmospheric Administration Diving Manual.

6. U.S. Navy Diving Manual (1973).

7. British Diving Standard, "Offshore Installation (Diving Operations) Regulations 1974, Statutory Instrument No. 1229".

8. Affidavit of Paul Woodhall, President, Professional Divers Local 1012, United Brotherhood of Carpenters and Joiners of America, formerly President International Association of Professional Divers, Inc.

9. "Compressed Air for Human Respiration Standard", prepared by Compressed Gas Association.

10. "Commodity Specification for Air, American National Standard," prepared by Compressed Gas Association.

11. U.S.C.G.—Reports Concerning Deaths of Commercial Divers.

12. NOAA—"An Analysis of the Civil Diving Population of the United States".

13. Oregon Safety Code—"Commercial Diving and Compressed Air Work."

14. "Hazardous Occupations and Avocations" from statistical Bulletin, Mar. '74 Metropolitan Life.

15. "The Effects of Abnormal Physical Conditions at Work: Medical Hazards of Diving."

16. Regulation for Control and Prevention, Occupational Diseases; Amended Nov. 11, 1964; Dept. of Commerce, Bureau of Workmen's Compensation, Tallahassee, Florida.

17. Underwater Association Code of Practice for Scientific Diving, Second Edition 1974; Natural Environment Research Council, London, England.

18. Santa Fe Engineering Corp., U.S. Gulf Coast Diving, Safety and Emergency Information.

19. The Principles of Safe Diving Practices CIRIA Underwater Engineering Group 6 Storey's Gate London, SWIP 3AU, London, England.

20. Comments received: a. Government of the District of Columbia Minimum Wage and Industrial Safety Board; b. Dept. of Transportation, U.S. Coast Guard; c. Dept. of Interior, National Park Service; d. National Oceanic and Atmospheric Administration.

21. Notices of Intent to Appear.

22. Notice of Hearing 10–22–75.

23. Dept. of Interior News Releases concerning OCS Lease Sale through 1978.

24. Dept. of Interior News Releases Leasing Schedule.

25. Estimates of Undiscovered Recoverable Resources, Production Profiles & Facilities Required. (Dept. of Interior)

26. Regulations Pertaining to Mineral Leasing Operation & Pipelines on the Outer Continental Shelf. (Dept. of Interior)

27. The Harry G. Armstrong Lecture: "Decompression Sickness: Advances and Interpretations" (A. Behnke)

28. "Medical Aspects of Commercial Diving and Compressed Air Work", E. Kindwall, in *Occupational Medicine, Principles & Practical Applications.*

29. "Selections and Training of Physicans and Paramedics for Offshore Diving", Preliminary Draft of Part 5T of the NIOSH–UMS National Plan for Safety and Health of Divers.

30. Statement of Andre Galerne.

31. "Compression and Decompression Protocols," Preliminary Draft of Part 2T of the NIOSH–UMS National Plan for Safety and Health of Divers.

32. "Effects of Drugs under Hyperbaric Conditions," Preliminary Draft of Part 11 of the NIOSH–UMS National Plan for Safety and Health of Divers.

33. "Selection & Training of Professional Divers," Preliminary Draft of Part 5 of the NIOSH–UMS National Plan for Safety and Health of Divers.

34. US underwater fatality statistics—1973.

35. Medical Research Report. EA 7104 Occupational Safety and Health Problem of the Diving Industry in Offshore Petroleum Production.

36. Theory & Development of Subsaturation Decompression Procedures for Depths in Excess of 400 feet.

37. Summary of Employee Relations Practice Patterns in the Diving Industry.

38. Minutes of 1st. Meeting, International Diving Contractors Assoc.—at No. 9 Upper Belgrave St., London, 17 July 1967.

39. Letter from S. Strauss (ADC) to OSHA commenting on Carpenter's petition.

40. Letters submitted by Ed Forsyth: A. Letter from Buckland; B. Letter from Hansen; C. Letter from Smith.

41. Representations by W. Hunter: A. List of Fatalities; B. Particulars of Darrel Taylor; C. Death Certificate of Dave McAllister; D. Records of James Johnson.

42. Diving in Construction Operations, National Safety Council Data Sheet.

43. Pg. 443, Hearing before Subcommittee on Labor of the Committee of Labor & Public Welfare, United States Senate—Ninety-Third Congress, Second Session—on a Review of the Occupational Safety and Health Act of 1970.

44. Article "Oil Rig, Diving Fatalities Mount." 10/23/75 *ENR* (Engineering News Record).

45. "Offshore deaths Worst Since 1965" Article *Offshore Engineer* Jan. 75.

46. Article "400 North Sea Divers are just not up to Standard" *Offshore Services* 2/75.

47. Statement of Len Andrew regarding the death of Mack Andrew, 8/7/69.

48. Medical report of Dr. Jenkins concerning Mr. James Onion.

49. Medical Report of Dr. Kindwall concerning Mr. Chandler Rashly.

50. A Diving Log of Mr. John Alvenus Aug. 23, 1972. B. Bends and Related Accident Depth on John Alvenus, Aug. 23, 1972.

51. 02 5th International Hyperbaric Congress proceedings 1973, Vol. II.

52. Letter from Stanley R. Strauss to OSHA concerning the incidence of bends, dated 10–20–75.

53. Preliminary comment of the ADC regarding hazards in commercial diving and the necessity of an emergency temporary standard, dated November 18, 1975.

54. Letter to H. W. Gillen, M.D. from Donald Boone, President International Association of Professional Divers, Inc. Dated 12/29/72

55. Comment of Donald Stevens, Diving Operations Supervisor, Normandeau Assoc.

56. Qualification of Joseph Carroll.

C. Post Hearing Comments:

PHC 1. Letter from Robert H. Harrison, Standards Specialist, Kentucky Department of Labor to Ms. J. Goodell, OSHA, dated November 11, 1975.

PHC 2. Letter from Jack S. Mixer, Logan Diving Inc., to Ms. J. Goodell, OSHA, dated November 11, 1975.

PHC 3. Letter from J. E. Logan, V. P. Logan Engineering & Contracting Co. to Ms. J. Goodell, OSHA, dated November 11, 1975 and attaching replies to Diving Standards Questionnaire.

PHC 4. Letter from W. J. O'Neill, Dive Director, Westinghouse Electric Corp. to Mr. Arnoldus, OSHA, dated November 18, 1975 attaching a paper entitled "Safety Considerations in Undersea Life Support."

PHC 5. Letter from Edward L. Beckman, M.D. to Jay Arnoldus, OSHA dated November 17, 1975, attaching a document entitled "Development of an Improved Decompression Table for Commercial Diving."

PHC 6. Article from October 75 issue of *Ocean Industries*, "North Sea work has high risks."

PHC 7. Letter from Eric P. Kindwall, M.D. to Jeffrey D. Doranz, Solicitor Office, to Jay Arnoldus, OSHA, dated November 26, 1975.

PHC 8. Letter from Peter A. Williams, Program Director Highline Community College. to Jay Arnoldus, OSHA, dated November 26, 1975.

PHC 9. Letter from Robert J. Pleasure, United Brotherhood of Carpenters and Joiners of America, to Nathaniel Spiller, Solicitor's Office, dated November 21, 1975 attaching a statement made before the Select Committee on the Outer Continental Shelf and Exhibits A–H.

PHC 10. Letter from James P. Moran, President, North Shore School of Skindiving, Inc. to OSHA, dated December 1, 1975.

PHC 11. Letter from J. F. Crofton, President Crofton Diving Contractors, dated, December 8, 1975.

PHC 12. Letter from Glen H. Egstrom, Ph.D., University of California, Los Angeles, to Jay Arnoldus, OSHA dated December 3, 1975.

PHC 13. Additional comments of the Association of Diving Contractors, dated December 8, 1975.

PHC 14. United Brotherhood of Carpenters and Joiners of America—"Memorandum In Support of Petition Requesting Adoption of Generally Recommended Safety and Health Procedures for Commercial Diving as an Emergency Temporary Standard Issued Under the Authority of the Occupational Safety and Health Act."

PHC 15. Letter of George H. R. Taylor, Executive Secretary, AFL–CIO Standing Committee on Occupational Safety and Health to Ms. Joanne Goodell, OSHA, dated December 8, 1975 with 2 attachments.

PHC 16. Statement of James R. Stewart, Diving Officer, University of California, San Diego, attaching the *Marine Technicians Handbook* of the Scripps Institute of Oceanography.

PHC 17. Telegram to OSHA from F. J. Van Antwerp, Durocher Dock and Dredge, Inc. dated December 5, 1975.

PHC 18. Telegram to OSHA from Podesta Divers, INC., dated December 1, 1975.

PHC 19. Letter from C. F. Logan, President, Logan Diving & Salvage Co. dated December 5, 1975 attaching portions of a NOAA Report dated March 15, 1975.

PHC 20. Letter from John P. Ripp, V.P.-Treas. Ripp-Tide to John Dunlop, Secretary of Labor, dated December 2, 1975.

PHC 21. Letter from Barry Sullivan, Washington Representative The National Association of Dredging Contractors, to John Dunlop, Secretary of Labor, dated December 5, 1975.

PHC 22. Letter from Rex Caffall II, of Trans Divers to Logan Diving Inc., dated December 3, 1975.

PHC 23. Letter from Joseph G. Elkins, Divers Inc. to OSHA December 5, 1975.

PHC 24. Letter from Larry B. Kennedy, Director, Administrative Services, Hydro Tech Inernational, Inc. to Mr. J. J. LoRocca, OSHA dated December 4, 1975.

PHC 25. Letter from Bill Boudreaux, Aqua Sports Inc. to John Dunlop, Secretary of Labor dated December 5, 1975.

PHC 26. Letter from Jack S. Mixer, V. P. Logan Diving Inc. To Mr. Joseph J. LaRocca, OSHA, dated December 1, 1975.

PHC 27. Letter from Central Pacific Divers to OSHA dated December 2, 1975.

PHC 28. Memo from Logan Diving Inc. to all Divers and Diving Companies dated November 26, 1975.

PHC 29. Letter from Ed Fite, Aqua-Venture dated December 1, 1975.

PHC 30. Letter from Habert C. Faitel, Dearborn, Chairman, "NIX ON OSHA" committee dated December 1975 attaching a pamphlet by Alan Stang entitled *OSHAcrats*.

PHC 31. Letter from J. E. Logan, President, Underwater Survey Inc.* to Mr. J. J. LaRocca, OSHA, dated December 3, 1975.

PHC 32. Copy of Letter from Phillip Burton, member of Congress to A. L. Podesta, manager, Podesta Divers, dated December 8, 1975.

PHC 33. Letter from Jon Hardy, General Manager, National Association of Underwater Instructors to OSHA dated December 9, 1975 with attachments.

PHC 34. Letter from C. F. Logan, Logan Diving & Salvage Co. to Joseph J. LaRocca, OSHA dated December 4, 1975, attaching portions of a NOAA report of March, 1975 and comments and suggestions applying to the ADC manual.

D. List of hearing exhibits.

E. Certification of hearing record with list of post hearing comments.

F. Letters from Congressmen and members of the public received after the certification of the hearing record (unnumbered).

G. National Institute for Occupational Safety and Health *et. al.*, National Plan for the Safety and Health of Divers in their Quest for Subsea Energy (10 reports) (NIOSH I).

H. National Institute of Occupational Safety and Health, NIOSH-Terrytown Labs-Undersea Medical Society Diving Standards Project Technical Narrative (preliminary report pursuant to "Safe Work Practices and Medical Procedures" contract on diving (NIOSH II).

I. "Dysbaric Osteonecrosis", in Davidson, J. K., ed. *Aseptic Necrosis of Bone* (New York, 1975) includes British Medical Research Council Decompression Registry techniques for skeletal radiological investigation of divers.

J. Directory of world-wide, shore-based hyperbaric chambers, Vol. I U.S. and Canada, NAVSHIPS 0994–010–4011 (1974).

K. U.S. Navy Diving Operations Handbooks, NAVSHIPS 0994–009–6010 (1974).

L. Underwater Zero-Gravity Simulation Trainer, NASA Marshall Space Flight Center, Huntsville, Alabama.

M. U.S. Coast Guard—Diving Fatality Reports.

N. "Medical Implications of Oil Related Industry", British Medical Association—Scottish Council.

O. Foreign diving standards—United Kingdom, France, Canada, Australia.

P. Report on the International Diving Symposium (Belle Chasse, La.)—1/75.

Q. Report on the International Diving Symposium (New Orleans, La.)—1/76.

R. Marine Technical Society Journal (Vol. 6—No. 1)—1/7/72.

S. Miscellaneous technical papers related to diving.

T. Miscellaneous newspaper and magazine clippings related to diving.

Accordingly, pursuant to sections 6(c) and 8(c) of the Occupational Safety and Health Act of 1970 (84 Stat. 1596, 1599, 29 U.S.C. 655, 657), Secretary of Labor's Order No. 8–76, and 29 CFR Part 1911, Part 1910 of Title 29 of the Code of Federal Regulations is hereby amended by adding a new Subpart T as set forth below.

Subpart T shall become effective on July 15, 1976.

1. Part 1910 is amended by adding the following Subpart to the table of contents.

Subpart T—Diving Operations

GENERAL

Sec.
1910.401 Scope and application.
1910.402 Definitions.
1910.403 Effective date.

PERSONNEL REQUIREMENTS

1910.410 Personnel qualifications.
1910.411 Medical requirements.

OPERATIONS PROCEDURES

1910.420 Safe practices manual.
1910.421 General operations procedures.
1910.422 Specific operations procedures.

DIVING EQUIPMENT AND SYSTEMS

1910.430 General.
1910.431 Helmets and masks.
1910.432 Dry suits (variable volume).
1910.433 Gas supply hoses.
1910.434 Air compressors and systems for respirable air.
1910.435 Human occupancy pressure vessels (HOPV).
1910.436 Depth gauges.
1910.437 Compressed gas equipment (except SCUBA cylinders).
1910.438 Equipment log.

RECORDKEEPING REQUIREMENTS

1910.440 Recording and reporting.
1910.441 Availability of records.

2. Subpart T is added as follows:

Subpart T—Diving Operations

GENERAL

§ 1910.401 Scope and application.

(a) This subpart applies to every place of employment within the inland and territorial waters of the United States, or within any State, the District of Columbia, the Commonwealth of Puerto

Rico, the Virgin Islands, American Samoa, Guam, The Trust Territory of the Pacific Islands, Wake Island, Johnston Island, the Canal Zone, or within the Outer Continental Shelf lands as defined in the Outer Continental Shelf Lands Act (67 Stat. 462, 43 U.S.C. 1331), where diving and related operations are carried out, except that this subpart will not apply to working conditions with respect to which other Federal agencies exercise statutory authority to prescribe or enforce standards or regulations affecting occupational safety and health.

(b) This subpart applies to diving and related operations conducted in connection with all types of work and all employments, including general industry, construction, ship repairing, shipbuilding, shipbreaking and longshoring.

(c) This subpart requires employers engaged in diving operations to be responsible for:

(1) Ensuring that all employees engaged in diving operations are competent to perform their work assignments in a safe and healthful manner, as provided in §§ 1910.410 and 1910.411;

(2) Developing, maintaining and complying with a safe practices manual, as provided in § 1910.420;

(3) Following safe and healthful operations procedures, as provided in §§ 1910.421 and 1910.422;

(4) Ensuring the use of appropriate tools, equipment and systems as provided in §§ 1910.430–1910.438; and

(5) Recording and reporting job-related fatalities and serious illnesses, injuries and accidents, and making all required records available to the Assistant Secretary for Occupational Safety and Health, in accordance with §§ 1910.440 and 1910.441.

§ 1910.402 Definitions.

As used in this subpart, the listed terms are defined as follows:

"Anti-suction devise": a device to prevent suction injury, which is used on the internal exhaust outlet of a human occupancy pressure vessel (HOPV); examples are a pipe nipple in which holes have been drilled or a wire cage.

"Bell diving": a mode of diving using a diving bell.

"Blowout": Uncontrolled loss of gas or liquid from a wellhead.

"Bottom time": the period of time between the beginning of descent to the bottom (working level) and the beginning of ascent from the bottom (working level).

"Breathing mixture": a mixture of gases and/or air breathed by a diver, containing an appropriate proportion of oxygen.

"Bursting pressure": the pressure exerted by a medium such as a breathing mixture at which the containment vessel theoretically fails structurally.

"Decompression": the controlled continuous reduction of environmental pressure to any intermediate depth level or to atmospheric pressure.

"Decompression chamber": a HOPV used to decompress divers by reducing pressure under safe and controlled conditions; it may also be used in the treatment of decompression sickness by recompression.

"Decompression table (protocol)": a time profile of pressure and breathing gas which reduces the pressure on the diver in a manner intended to prevent decompression sickness.

"Diver": an employee who uses equipment underwater which supplies compressed breathing gas from a self-contained source or remote source, enabling him to breathe under water at ambient pressure.

"Diving bell": a device which allows the diver to be transported to and from the underwater work site in an enclosed, dry compartment. The bell may have an open bottom, or it may be sealed.

"Dry suit (variable volume)": a diving suit capable of being inflated for buoyancy or insulation, which keeps the diver's body essentially dry. A "wet suit", in contrast, allows water to contact the diver's body.

"Employer": a person engaged in a business affecting commerce who has employees, but not including the United States or any State or political subdivision of a State. See 29 CFR Part 1975.

"Exhaust valve": a valve controlling the venting of gas from a HOPV, diver's helmet, or suit.

"FSW": a foot of sea water; a unit of pressure generally defined as 1/33 of a standard atmosphere, which represents the pressure exerted by a foot of water having a specific gravity of 1.027.

"Hard piping": permanent or semi-permanent, rigid piping, as distinguished from temporary, flexible hoses.

"Helmet (open-circuit and/or surface-supplied)": breathing and protective equipment which covers the diver's head.

"HOPV": Human Occupancy Pressure Vessel. A pressure vessel which, in normal operation, is intended to contain a human being.

"Life-support equipment": equipment designed to provide an appropriate respirable atmosphere and other protection, e.g., thermal, as required.

"Live-boating": the practice of supporting a diver from a vessel which is underway.

"Mask (open circuit and/or surface-supplied)": breathing and protective equipment which covers a diver's face.

"Mixed-gas diving": a diving mode in which the diver is supplied with a gas mixture other than air.

"No-decompression diving": diving which involves depths and times shallow and short enough so that controlled ascent can be made without stops or stages.

"Non-return valve": a one-way check valve installed at the point where the hose attaches to the diver's helmet, designed to prevent the loss of helmet breathing mixture or to prevent a suction should the hose be cut or the gas supply fail.

"Oxygen cleaning": special cleaning precautions that must be taken to ensure that oxygen under pressure does not ignite flammables on contact.

"Oxygen compatibility": the ability to come into contact with high pressure oxygen without oxidation occurring.

"Pneumofathometer": a device for measuring depth by slowly forcing air or gas through a tube from the surface to the site to be measured. The pressure required to force gas to the end of the tube is the pressure exerted on the outlet of the tube.

"Receiver": a pressure vessel for the storage of gases (except SCUBA cylinders).

"Repetitive dive": a dive where the decompression requirement is increased by a preceding dive or dives.

"Saturation diving": a mode of diving in which the diver's body is essentially saturated with inert gas; additional time spent at pressure does not therefore result in additional uptake of gas nor require an increase in decompression time.

"SCUBA": self-contained underwater breathing apparatus. See self-contained diving.

"Self-contained diving": a diving mode which allows the diver to carry his own breathing gas supply and be independent of the surface with regard to breathing gas.

"Stage decompression": the controlled reduction of environmental pressure with programmed stops at various depths.

"Standby diver": a diver suited and ready to go to the aid of another diver.

"Surface-supplied diving": a mode of diving in which the diver receives breathing gas by hose from the surface.

"Working pressure": the normal operating pressure exerted by a medium such as a breathing mixture. The ratio of the bursting pressure to the working pressure is the factor of safety.

§ 1910.403 Effective date.

This subpart is effective July 15, 1976.

Personnel Requirements

§ 1910.410 Personnel qualifications.

(a) *General.* Each employer engaged in diving operations shall ensure that all employees engaged as divers or in surface support operations are competent to perform their work assignments in a safe and healthful manner, in accordance with the provisions of this subpart.

(b) *Employee competence.* Employee competence, which must be ensured by the employer, shall include at least the following:

(1) Knowledge and skills in diving gained through training or experience, including among other things knowledge of:

(i) Diving procedures and techniques,

(ii) Emergency procedures,

(iii) Physiology as it relates to diving, and

(iv) Diving equipment;

(2) Familiarity with procedures and proficiency in the use of tools, equipment and devices relevant to the assigned tasks; and

(3) For employees engaged as divers, physical qualifications for such activities,

as determined in accordance with the requirements of § 1910.411.

(c) *Competence training.* Where an employee does not possess competence in the safe use of a tool, equipment, or device, or knowledge of diving procedures and techniques as required by this section, the employer shall require the employee to undergo appropriate training or shall assign another employee who possesses necessary competence.

§ 1910.411 Medical requirements.

(a) *General requirements.* Every employer shall provide or make available at no cost to the employee the services of a licensed physician to perform medical examinations, as required by this section, for all employees engaged as divers, so as to establish the employee's physical qualifications to perform the assigned tasks.

(b) *Information provided to the examing physician.* The employer shall provide the following information to the examining physician:

(1) A copy of this subpart.

(2) A description of the affected employee's duties for which he is being examined, and of the physical demands placed upon the employee by said duties.

(3) Upon request of the physician, information from previous reports of physicians concerning the affected employee.

(c) *Initial examination.* (1) Within 30 days after the effective date of this subpart, all employees engaged as divers shall be provided an initial medical examination, except as described in paragraph (c)(2) of this section, which shall include the following:

(i) A complete work history;

(ii) All the tests listed in Table I; and

(iii) Any additional tests deemed necessary by the examining physician to prepare the written report required by paragraph (f) of this section.

(2) If an employee can show, to the satisfaction of the employer after consultation with the examining physician, that within one year prior to the effective date of this subpart, he has had a comprehensive medical examination comparable to the examination required by this section, and that the results of this examination did not indicate the presence of any of the conditions listed in paragraphs (f)(1)(ii) or (h) of this section, no initial examination is required, unless there is reason to believe that the employee's medical condition has changed in the interim. In any event, at the termination of one year from the date of his comparable medical examination, such employee shall be given an initial medical examination as required in paragraph (c)(1) of this section.

(d) *Re-examination after injury or illness.* Following an injury or illness to a diver requiring 72 hours or more hospitalization, or requiring treatment by an attending physician for a period of at least 5 days, or involving decompression sickness with vestibular or central nervous system dysfunction, the employer shall provide or make available, at no cost to the employee, a medical examination. The employee shall not be permitted to return to work as a diver until, based on the physician's report, he is physically fit to do so. The examining physician shall determine the scope of the examination in light of the nature of the injury or illness.

TABLE I—MEDICAL TESTS FOR DIVING

Tests	*Comments*
History and physical	Include predisposition to unconsciousness, vomiting, cardiac arrest, impairment of oxygen transport, serious blood loss, or anything which, in the opinion of the examining physician, will interfere with effective underwater work.
Chest X-ray	PA (Projection: 14 by 17).
Bone and joint X-ray	Required only for divers involved in decompression dives. British Medical Research Council techniques and interpretation recommended. (See app. B.)
EKG: STD (12L)	Baseline.
EKG: Stress	
Pulmonary function	Required only if medically indicated. Proved and mechanical capacity calculated for: FEV (forced expiratory reserve volume); FVC (forced vital capacity); and MEFR (maximum expiratory flow rate).
Audiogram	In accordance with American National Standard Specifications for Audiometers, ANSI S3.6–1969(R1973).
Dry chamber	Required only for divers involved in decompression dives, if medically indicated. The test is as follows: The diver is taken to 165 FSW (6 ATA) in a chamber to test his ability to withstand pressure and to clear his ears.
EEG	Required only if medically indicated.
Visual acuity and color blindness.	
Complete blood count	
Routine urinalysis	

(e) *Alternative medical examinations.* If the examining physician determines that medical examinations and tests other than those specified in this section and Table I would be at least equally effective in determining a diver's physical qualifications, the employer may accept such medical examinations and tests, provided that the employer obtains a statement from the physician setting forth the alternative examination and the rationale for substitution and informs each affected employee of the fact that such alternative examination will be made available.

(f) *Physician's written report.* (1) With respect to each medical examination required by this section, the employer shall obtain a written report from the examining physician, containing the following information:

(i) A statement indicating the results of the medical examinations and tests given in accordance with this section;

(ii) An opinion, based on the employee's medical history and the results of the tests required in Table I, as to whether exposure to the physical demands placed upon the employee by the duties in which he will be engaged would result in any of the following:

(A) Increased risk of material impairment of the employee's health;

(B) Excessive stress to the pulmonary, muscular, cardiac, and skeletal systems;

(C) Interference with the effective external communication of the gas-containing organs of the body;

(D) Excessive burden on the central and peripheral nervous system; or

(E) Aggravation of any existing radiological evidence of aseptic bone necrosis;

(iii) An opinion as to whether the employee, on the basis of his medical history and the results of the examination and required tests, has any of the conditions listed in paragraph (h) of this section;

(iv) Any recommended limitations upon the employee's activities as a diver; and

(v) A statement that the employee has been informed by the examining physician of any medical conditions which require further examination or treatment.

(2) The written report shall not reveal specific findings or diagnoses unrelated to occupational exposure to the underwater environment.

(3) A copy of the physician's written report shall be provided to the employee. In addition, any materials in the employee's medical file pertaining to the medical examination required by this section shall be made available to the employee or former employee examined, upon written request by the employee or his representatives.

(g) *Withdrawal of employee.* The employer shall determine, on the basis of the physician's written report or any opinions by a consulting physician, whether an employee's health would be materially impaired, in any manner indicated in paragraph (f)(1) of this section, by continued diving, or whether there are necessary limitations on the employee's activities as a diver. If indicated by the determination, the employer shall withdraw the employee from such exposure or shall appropriately limit the employee's activity.

(h) *Disqualifying conditions.* If an employee has any of the following conditions, as found by the examining physician, the employer shall withdraw the employee from diving:

(1) History of epileptiform disease or syncopal attacks;

(2) Cystic or obstructive disease of lungs;

(3) Chronic inability to equalize sinus and middle ear pressure;

(4) Significant central nervous system disease;

(5) Significant joint disorders of the shoulder, hip, or knee;

(6) Significant cardiac abnormalities; e.g., pathological heart block, valvular disease, interventricular septal defects etc.; and

(7) Chronic alcoholism.

(i) *Medical recordkeeping.* The employer shall establish and maintain an accurate medical record for each employee subject to the medical requirements of this section.

(1) The record shall include:

(i) Physician's written reports; and

(ii) A copy of the information provided to the physician as required by paragraph (b) of this section.

(2) This record shall be maintained by the employer for at least 5 years and shall be made available as provided in § 1910.441.

(3) Upon request by the employee or former employee, the employer shall transfer the employee's medical record or a copy thereof to a physician designated by the employee or former employee or to another employer.

OPERATIONS PROCEDURES

§ 1910.420 Safe practices manual.

(a) *General.* (1) Each employer engaged in diving operations shall develop and maintain a safe practices manual and shall follow the procedures set out in such manual for all diving operations.

(2) The manual shall specifically incorporate and be in accordance with the requirements of this subpart, and shall be developed so as to provide for the safety and health of employees involved in diving operations.

(b) *Content.* (1) The manual shall contain comprehensive safety and health requirements for each type of diving operation engaged in by the employer.

(2) These requirements shall include provisions for:

(i) The assignment of competent employees, to enable the operation to be performed without jeopardy to the safety and health of the employees involved;

(ii) General and specific operations procedures which shall incorporate and be consistent with applicable procedures contained in this subpart;

(iii) The use of appropriate tools, equipment and systems, which shall comply with the requirements of §§ 1910.430–1910.438;

(iv) Fire, emergency and evacuation procedures in accordance with paragraph (d) of § 1910.421, and for the rescue or retrieval of manned HOPV's in accordance with paragraphs (c) and (e) of § 1910.422.

(c) *Availability.* The manual shall be readily available at the work site, shall be provided to all employees involved in diving operations, and shall be made available, upon request, to the Assistant Secretary or his designee.

§ 1910.421 General operations procedures.

(a) *General.* All diving operations shall comply with the operations procedures contained in this section. These procedures shall, in accordance with § 1910.420, be included in the safe practices manual.

(b) *Emergency aid.* (1) The employer shall develop and maintain a list of the available sources of emergency aid, equipment, and professional assistance, with their call or phone numbers, and instructions for establishing contact with them. The list shall be available at the work site, at the employer's principal place of business and at the field operations offices. This list shall include, at least, the following forms of emergency aid as appropriate for the type of diving operations engaged in:

(i) Decompression chamber;

(ii) Hospital or medical treatment facility;

(iii) Air transportation;

(iv) Consulting physician; and

(v) U.S. Coast Guard Search and Rescue Unit.

(2) Two-way communications, necessary to the requisition of the emergency aid, equipment, and professional assistance listed in paragraph (b)(1) of this section, shall be available or accessible to the work site.

(c) *First-aid.* (1) First-aid supplies, approved by a consulting physician, including a copy of the *American Red Cross Advance First-Aid Manual*, shall be readily available at the work site.

(2) A mechanical or automatic oxygen resuscitator, with sufficient oxygen supply and in proper working order, shall be ready for immediate use at the work site.

(3) In the absence of a physician at the work site, an employee who has a valid certificate in first-aid training from the American Red Cross, or equivalent training, including training in the use of an oxygen resuscitator, shall be available at the work site to render first-aid.

(d) *Fire and emergency procedures—*(1) *Fire fighting equipment.* Fire fighting equipment shall be available and ready for use at the work site whenever sources of ignition and flammable or combustible materials are present.

(2) *Emergency procedures plan.* (1) The employer shall establish and comply with an emergency procedures plan, which shall include steps to be taken in case any of the following emergencies occur during the dive, including the decompression interval:

(i) Loss of voice communications;

(ii) Interruption of the surface gas supply;

(iii) Parting of the diver's life support hose bundle (umbilical);

(iv) Diver entanglement or entrapment;

(v) Oxygen poisoning;

(vi) Decompression sickness;

(vii) Unplanned positive buoyant ascent (blowup);

(viii) Physical injury; or

(ix) Acute illness.

(3) *Fire and emergency evacuations.* The employer shall ensure that prior to commencing diving operations at the work site, all members of the diving team are familiar with the emergency procedures including emergency evacuation procedures, the fire fighting procedures, and the emergency station assignments.

(4) The emergency procedures plan shall be included in the safe practices manual required by § 1910.420.

(e) *Hazards to diving operations.* (1) The employer shall notify those in the vicinity whose activities may interfere with or pose a hazard to the diving operations, such as underwater blasting or movement of surface vessels, of the planned diving operation and daily start and finish times.

(2) Whenever hazardous activities in the vicinity of the diving operations, or whenever conditions, such as weather or sea-state, are such that they may interfere with the ability of an employee to perform safely underwater or impair his health, the employer, after consultation with the affected employee, shall not allow such employee to dive for the duration of such hazardous activity or adverse condition.

(f) *Temporary impairments.* The employer shall ensure that no employee dive for the duration of a temporary physical impairment such as a cold, alcoholic intoxication or its after effects, influence of drugs, respiratory or middle ear disease, skin or external ear infection, excessive fatigue or emotional distress, even if not an injury or illness described in § 1910.412(d), if the impairment is likely to materially interfere with the employee's ability to perform safely underwater, or impair his health. The employer shall consult with the affected employee before making such determination and in no event shall require an employee to dive against the employee's will.

(g) *Inspection of tools, equipment and operational systems.* (1) The employer shall ensure that all tools, equipment, and operational systems used in diving operations are appropriate, in proper working order, and in compliance with §§ 1910.430–1910.438.

(2) Tools, equipment, and operational systems used in diving operations shall be inspected at the commencement of each day's diving operations, and monitored throughout the operations, by the person immediately in charge of the diving operation in which they will be used.

(3) The employer shall ensure that each employee engaged as a diver in the diving operation shall inspect the equipment and tools to be used personally by him.

(h) *Pre-dive instructions.* (1) Prior to commencing and engaging in each diving operation, the employer shall instruct each employee involved as to the details of the procedures to be followed in the operation, and as to appropriate fire and emergency procedures.

(2) For each diving operation varying from or supplementing the personnel, procedures, tools, equipment and systems or emergency requirements described in

the safe practices manual, the employer shall give specific instructions covering the additional information necessary to ensure safety and health. Where known to the employer sufficiently in advance of the diving operation, the essential information shall be reduced to writing and a copy shall be given to affected employees.

(i) *Means for entering and leaving the water.* The employer shall provide safe means for entering the water from the diving platform and for leaving the water for employees engaged as divers and for the rescue of the surface support personnel in the event they fall into the water.

(j) *Human occupancy pressure vessel (HOPV).* A HOPV, specifically a decompression chamber, shall be available and ready for use at the work site, for any dive in which stage decompression in excess of 30 minutes is involved.

(k) *Thermal exposure.* Special precautions shall be taken by the employer to protect any employee from adverse thermal exposure while engaged in diving.

(l) *Standby diver.* A qualified standby diver shall be suited and ready to reach a diver in the water within 5 minutes, whenever dives are made in excess of 100 FSW requiring stage decompression, or in shallower depths when warranted by the nature of the work or exposure. Two divers in the water working together shall be considered as meeting this requirement.

(m) *Underwater hazardous conditions.* (1) Whenever a diver enters any structure, tunnel, wreck, pipe, or other similarly restricted area underwater, a standby diver shall be available at the point of entry to tend the diver who is within the restricted area.

(2) Special precautions shall be taken by the employer to protect any employee diving in the vicinity of underwater suction hazards, such as sluices, major inflow/outflow pipes and the like.

(n) *Warning display.* In addition to any other warning signals used, the following warning signals shall be displayed at the diving operation site, so as to be visible for 360 degrees around the horizon during daylight operations:

(1) Where diving is done from any vessel in international waters, a rigid replica of the international flag "A" (white and blue pennant), not less than one meter in height.

(2) Where diving is done from any other worksite, the American dive flag. This flag shall be square and have a red field with a white diagonal stripe from the upper hoist to the lower fly. The width of the diagonal stripe shall be one-fourth of the length of the flag's side. Stiffening shall be used if necessary to ensure all around visibility. Where diving takes place from vessels and waterborne platforms less than 65 feet in length, the flag shall be at least 0.6 meter square. Where diving takes place from other platforms, including fixed structures such as piers, the flag shall be one meter square.

(o) *Reserve breathing gas supply.* A reserve breathing gas supply shall be provided for each diver engaged in a diving operation requiring stage decompression. The supply shall be sufficient for life support until the diver can be safely returned to a place of refuge or to the surface.

(p) *Decompression protocols.* Appropriate decompression protocols, including decompression schedules or tables which are devised in accordance with tested physiological criteria, shall be adhered to. The protocols shall be used only for the diving operations for which they were designed. These decompression protocols shall be included in the safe practices manual and available at the dive site.

(q) *Communications.* An operating, 2-way audio comunications system shall be provided for communications between the diver and the surface (tender), except as permitted by paragraph (a)(1) of § 1910.422.

(r) *Diver's personal equipment.* A sharp knife shall be carried by all divers while in the water.

(s) *Employer's record of dives.* (1) The employer shall make and maintain a record of information concerning each diving exposure to which each diver is subjected. The record shall contain the following:

(i) Name and address of the employer;

(ii) Location and date of diving operation;

(iii) Names of divers, tenders, and person immediately in charge of the diving operation;

(iv) Depth of dive;

(v) Bottom time;

(vi) Type of equipment used;

(vii) Estimated environmental conditions (sea state, underwater visibility, water temperature, and underwater currents);

(viii) Decompression schedule used;

(ix) Gas used and composition;

(x) Type of work performed;

(xi) Type of diving equipment worn;

(xii) Any unusual conditions (other than environmental); and

(xiii) Repetitive dive designations, or time of last pressure exposure.

(2) For a diving operation involving more than one diver, where the exposures are uniform, a single record applicable to all divers is sufficient. Where the exposure of any diver varies in any respect, a separate record of these variations shall be kept.

(3) These records shall be maintained by the employer for at least 5 years.

§ 1910.422 Specific operations procedures.

In addition to the general operations procedures required by § 1910.421, employers engaged in diving operations shall comply with the following specific operations procedures contained in this section.

(a) *Self-contained diving.* (1) The communications required by paragraph (q) of § 1910.421 need not be provided for an employee engaged in a self-contained diving operation who is accompanied by another diver (buddy), or who can communicate with the surface tender through a safety line using pull signals.

(2) The planned time of a self-contained diving operation, including decompression time, shall not exceed the air supply duration of the cylinders (without regard to the reserve emergency cylinders).

(3) The cylinder pressure shall be determined immediately before each dive.

(b) *Surface-supplied diving.* (1) The employer shall assign a sufficient number of employees to each diving operation to ensure the safety and health of the employees engaged as divers and to make possible effective response in case of an emergency.

(2) The depth of each dive shall be determined prior to the start of operations.

(c) *Saturation diving.* The employer shall develop and include in the safe practices manual an evacuation plan for saturation diving, for rescue or retrieval of all manned HOPV's in such emergencies as:

(1) Storms or blowouts, requiring evacuation of the work site (work platform); or

(2) After loss of power which affects the ability to maintain life support systems.

(d) *Mixed-gas diving.* (1) The breathing mixture shall be composed of a mixture of gases that is physiologically appropriate for the depth and duration of the dive.

(2) Air shall not be used as the breathing mixture for dives in excess of 220 FSW. Dives between 190 FSW and 220 FSW on air shall be limited to 10 minutes bottom time.

(e) *Bell diving.* (1) A minimum of 2 divers shall be used for all dives where a closed diving bell is used.

(2) The employer shall develop and include in the safe practices manual an evacuation plan for rescue or retrieval of the bell in case of an emergency requiring rescue. A standby diver shall be on site to attend the bell at the surface in an emergency.

(3) (i) Open or closed bells shall be provided and used for al dives of 220 FSW and deeper, and for all dives which require more than 120 minutes of in-water decompression time.

(ii) Closed bells shall be provided and used for all dives of 300 FSW and deeper.

(f) *Live-boating.* (1) When live-boating, a protective device shall be installed to prevent the hose from becoming entangled in the propeller.

(2) The employer shall ensure that divers engaged in the live-boating operation carry a reserve breathing gas supply.

(3) A standby diver shall be available, in accordance with paragraph (l) of § 1910.421, for all live-boating operations.

Diving Equipment and Systems

§ 1910.430 General.

Employers engaged in diving operations shall ensure the use of tools, equipment and systems which comply with the requirements of this subpart.

§ 1910.431 Helmets and masks.

(a) *General.* (1) All open-circuit helmets and masks (except oral-nasal)

shall be capable of ventilating at least 4.5 cubic feet per minute (cfm) of gas when supplied at the pressure recommended by the manufacturer of the equipment.

(2) An operating, 2-way, audio-communication system shall be incorporated into all helmets and masks used for diving operations. This requirement need not be met in the case of a SCUBA diver (self-contained diver) who is accompanied by another diver (buddy), or can communicate with the surface tender through a safety line using pull signals.

(b) *Surface-supplied helmets and masks.* (1) All surface-supplied helmets and masks shall be equipped with non-return valves.

(2) Surface-supplied helmets and masks used in salt water shall be made of materials resistant to corrosion from salt water.

(3) Surface-supplied helmets and masks shall seal readily and positively and be capable of ventilating at least 4.5 cfm of gas when supplied at the pressure recommended by the manufacturer of the equipment, as provided in paragraph (a) (1) of this section.

§ 1910.432 Dry suits (variable volume).

Dry suits or similar buoyancy changing equipment shall be equipped with exhaust valves to minimize the possibility of blowup.

§ 1910.433 Gas supply hoses.

(a) *Rating of gas supply hoses.* (1) Gas supply hoses shall have a rated bursting pressure of at least 4 times greater than their maximum working pressure.

(2) In no case shall the working pressure be less than the maximum depth of the dive (converted to pounds per square inch (psi)) plus 100 psi.

(b) *Properties of gas supply hoses.* Hoses shall be kink resistant and capable of the required flow rates for the system used.

(c) *Testing of gas supply hoses and fittings.* (1) Gas supply hoses and fittings shall be tested at least annually to twice their maximum working pressure plus 100 psi. In addition, such testing shall be done after each exposure to rough usage, or unusual conditions.

(2) Information concerning the tests performed on gas supply hoses and fittings shall be entered in the equipment log in accordance with the requirements of § 1910.438.

(d) *Marking of gas supply hoses.* (1) All hoses shall be marked in 10 ft. increments starting at the diver's end, up to 50 ft., and at 50 ft. increments thereafter, to enable the tender to determine how much hose is payed out.

(2) Hoses shall not be used for determining depth. A pneumofathometer or similarly reliable and accurate method shall be used instead.

(e) *Resistance of hose fittings to salt water.* All hose fittings used in salt water service shall be made of materials resistant to corrosion in such a medium, such as brass, stainless steel, monel or other material equally resistant to corrosion.

(f) *Design of hose fittings.* The connections of all hose fittings shall be of a type that cannot be accidentally disengaged from the compressor or gas system.

(g) *Protection of hoses.* All gas supply hoses shall be taped, capped or plugged when not in use to prevent foreign matter from entering the hoses.

(h) *Oxygen cleaning of hoses.* When oxygen cleaning is necessary to prevent ignition of ignitable gases or other materials within the hoses with oxygen, when placed into use, the cleaning process shall be described in the equipment log, in accordance with § 1910.438. Steps shall be taken to prevent contamination between the time of cleaning and the use of the equipment.

§ 1910.434 Air compressors and systems for respirable air.

(a) *Volume tanks or receivers.* Volume tanks or receivers manufactured after the effective date of this subpart and used in compressed air systems for respirable air shall comply with the design and construction requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels–1976. Tanks or receivers manufactured before the effective date of this subpart shall be maintained in conformity with the code requirements to which they were built. Tanks or receivers which are subject to U.S. Coast Guard approval procedures, shall be used only if they have such approval. All volume tanks or receivers shall be equipped with a check valve on their inlet side, a pressure gauge, and a relief valve set so as to prevent pressure buildup in excess of the maximum working pressure.

(b) *Recording of maintenance and repairs performed.* An entry shall be made in the equipment log, in accordance with § 1910.438, of all maintenance and repairs performed on the compressors and the air systems. These entries shall include such information as belt or oil changes on the compressor, any engine maintenance or repairs performed, or any other change or repair to any part of the air system, such as a filter change.

(c) *Air purity requirements.* Air supplied as a breathing mixture to a diver shall not contain a level of carbon monoxide greater than 20 parts per million, or a level of carbon dioxide greater than 1,000 parts per million. The air shall be devoid of any noxious or pronounced odor.

(d) *Air compressor intakes.* All air compressor intakes shall be located in an area free of exhaust fumes and other contamination. The air intakes of air compressors permanently installed in an enclosed space shall be piped externally to a source clear of exhaust fumes and other contaminants.

§ 1910.435 Human occupancy pressure vessels (HOPV).

(a) *General HOPV requirements.* Human occupancy pressure vessels manufactured after the effective date of this subpart shall conform to the requirements of ASME Boiler and Pressure Vessel Code, Section VIII, Unfired Pressure Vessels—1976. HOPV's manufactured before the effective date shall be maintained in conformity with the code requirements to which they were built. HOPV's which are subject to U.S. Coast Guard approval procedures shall be used only if they have such approval. They shall be labelled accordingly.

(b) *Oxygen piping on HOPV's.* (1) Hard piping systems, fittings, and tubing carrying pure, high pressure (up to 2500 psi) oxygen shall be made of corrosion resistant metals, such as copper, brass, 300 series stainless steel, or monel.

(2) HOPV internal oxygen outlets shall have non-return valves or shut-off valves.

(3) All shut-off valves used in an oxygen system above 125 psi shall be of the slow-opening type, such as a needle type valve.

(c) *Installed oxygen system.* On HOPV's with installed oxygen decompression systems, a means shall be provided to prevent the oxygen concentration from rising above 25 percent of the atmospheric content. A means shall also be provided to enable a continuous reading of the oxygen concentration when the HOPV is in operation.

(d) *Fire protection.* All HOPV's shall be designed and equipped to eliminate internal combustible materials and sources of ignition to the extent feasible.

(e) *Illumination.* All HOPV's shall be illuminated to permit continuous visual observation of the diver from the exterior.

(f) *Anti-suction device.* An anti-suction device shall be installed inside the HOPV on the exhaust outlet.

(g) *Audio-communication.* An operating, 2-way, audio-communication shall be provided while a HOPV is in operation.

§ 1910.436 Depth gauges.

(a) *Testing and calibration.* (1) Depth gauges shall be deadweight tested or calibrated against a master-reference gauge every six months, or any time there is reason to believe they are not functioning properly. A card or label shall be attached to the gauges showing date of test or calibration.

(2) An entry shall be made in the equipment log, in accordance with § 1910.438, identifying the gauges tested or calibrated and describing the type of testing or calibration performed.

(b) *Installation to allow checking.* Depth gauges shall be so installed as to allow a system check of their accuracy.

§ 1910.437 Compressed gas equipment (except SCUBA cylinders).

(a) *Securing of cylinders.* Compressed gas cylinders shall be stored in a well ventilated area, protected from heat, and secured from falling.

(b) *Protection cap.* Compressed gas cylinders shall have a protection cap over the cylinder neck and valve when not in use.

(c) *Pressure regulator (Oxygen).* Oxygen systems shall employ oxygen compatible pressure regulators to control flow.

§ 1910.438 Equipment log.

(a) The employer shall have and maintain an equipment log in which at least the following information shall be entered:

(1) The procedures followed in testing gas supply hoses and fittings and the results of such tests.

(2) The procedures followed in the oxygen cleaning of hoses and the methods and materials used to assure cleanliness. The hoses and fittings used in oxygen service shall be identified by a tagging system or similar method.

(3) The maintenance and repairs to the air compressor and the air system.

(4) The testing and calibration of depth gauges.

(b) For each entry in the equipment log, the equipment or part shall be identified, the nature of the work shall be described, the date on which the work is performed shall be noted, and the individual performing the work shall sign and print his name together with the name and address of the company or employer by whom he is employed.

(c) The equipment log shall be kept by the employer for a period of at least 5 years.

RECORDKEEPING REQUIREMENTS

§ 1910.440 Recording and reporting.

(a) *Recording.* The recording of occupational injuries and illnesses by employers shall be in accordance with the requirements of 29 CFR Part 1904.

(b) *Reporting.* (1) The employer shall report to the Area Director of the Occupational Safety and Health Administration, U.S. Department of Labor, the occurrence of any of the following employment related accidents, injuries, or illnesses:

(i) Any fatality;

(ii) Any hospitalization of five or more employees;

(iii) Any injury or illness to any diver requiring 72 hours or more hospitalization;

(iv) Any injury or illness to a diver requiring at least 5 days treatment by an attending physician;

(v) Decompression sickness with vestibular or central nervous system dysfunction.

(2) The report shall be made within 48 hours after the occurrence. It may be either oral or in writing, by telephone or telegram. The report shall relate the circumstances of the accident, the number of fatalities, and the extent of any injuries or illnesses. The Area Director may require such additional report, in writing or otherwise, as he deems necessary concerning the accident.

§ 1910.441 Availability of records.

(a) *Inspection of records.* Upon the request of an authorized representative of the Assistant Secretary for Occupational Safety and Health, the employer shall make available for inspection and copying any manual, written instruction, record, or log that is required to be kept by this subpart.

(b) *Transfer of records.* In the event the employer ceases to do business, the successor employer shall receive and retain all records required to be maintained by this subpart.

APPENDIX A—MEMORANDUM OF UNDERSTANDING BETWEEN THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION OF THE DEPARTMENT OF LABOR AND THE UNITED STATES COAST GUARD OF THE DEPARTMENT OF TRANSPORTATION

This Memorandum of Understanding is entered into by the Occupational Safety and Health Administration (OSHA), Department of Labor, and the United States Coast Guard (USCG), Department of Transportation.

I. PURPOSE

This Memorandum of Understanding is entered into for the purpose of:

(1) Providing the basis upon which OSHA and the USCG shall cooperate on occupational safety and health matters pertaining to diving operations;

(2) Implementing and enforcing the OSHA Emergency Temporary Standard (ETS) on diving operations, to be published in June 1976, issued pursuant to Section 6(c) of the Occupational Safety and Health Act (the Act), 29 USC 655;

(3) Coordinating logistical support necessary to the proper conduct of ETS regulatory activities;

(4) Providing a procedure for interagency consideration of questions of respective Agency responsibilities which may arise in the course of administering the ETS;

(5) Providing for a tentative joint rulemaking procedure for developing permanent standards (regulations) for diving operations.

II. IMPLEMENTING PROCEDURES

(1) General. a. The Assistant Secretary of Labor for OSHA and the Commandant of the USCG shall each designate one senior official, who shall be responsible for coordinating and effectuating the provisions of this Memorandum.

b. Each Agency shall establish procedures for the dissemination to the other Agency of information and documents pertinent to enforcement of the ETS.

(2) Enforcement of ETS: a. Inspections of work sites involving vessels inspected by the USCG, deepwater ports, and artificial islands and fixed structures on the Outer Continental Shelf, shall be made jointly by personnel from each Agency. Citations issued by OSHA for violations of the ETS, and proceedings on these citations shall be pursuant to the Act and implementing regulations.

b. Accident and complaint investigations shall have priority over general scheduled inspections.

c. Inspection scheduling shall be coordinated between the Agencies by the OSHA area director and the local USCG Officer-in-Charge, Marine Inspection.

d. Inspections of all other work sites covered by the ETS made jointly by compliance officers from each Agency, except where at the determination of the USCG such USCG personnel are not readily available.

e. No advance notification of inspections shall be given to the employer/operator of affected work sites except where notice is necessary to assure the safe arrival and departure of compliance personnel.

(3) Logistics and Support. a. Pursuant to 14 USC 141, the USCG may provide OSHA such logistical and administrative support as may be required to implement the ETS.

b. When access to an offshore worksite is required, the USCG may furnish transportation to compliance personnel. When in the judgment of the U.S. Coast Guard District Commander such resources are not reasonably available because of other Coast Guard missions of higher priority, the OSHA area director may secure transportation from private charter sources.

III. INTERPRETATIONS AND POLICY DEVELOPMENT

(1) Interpretation of Memorandum: a. Each Agency shall interpret its assigned responsibilities in a manner which best achieves the purposes of this Memorandum.

b. In the event a dispute arises concerning interpretation of this Memorandum, the matter shall be brought as soon as possible to the attention of the OSHA regional Administrator and the local USCG District Commander for resolution.

c. If the matter is unable to be solved at the local level, it shall be promptly referred to the designated senior Agency officials, who shall confer and seek mutual resolution.

(2) Policy Cordination: a. A committee composed of three representatives of each Agency shall be established to:

(1) Evaluate regulatory policy of the Agencies with respect to commercial diving;

(2) Review legislative initiatives affecting the scope of this Memorandum, and

(3) Coordinate Agency positions regarding legal issues raised in the course of enforcing or administering the ETS.

IV. PROCEDURE FOR PROMULGATING A PERMANENT STANDARD (REGULATION)

(1) General: a. To the maximum extent possible under existing statutes and regulations, each agency shall cooperate fully with the other to promulgate a final permanent standard (regulation) within six months from the effective date of the ETS.

b. Agency resources and expertise shall be shared and exchanged for the duration of the project.

c. All relevant information and data shall be freely exchanged.

d. Necessary agency clearances and approvals shall be expedited and given priority status.

(2) Conduct of the Rulemaking Procedure: a. If practicable, public activities pursuant to this rulemaking activity shall be conducted under the joint auspices of OSHA and the USCG.

b. To the maximum extent possible, all documents relevant to the conduct of the rulemaking proceedings shall be jointly developed.

c. Public input, including opportunities for hearings and comments shall be maximized and encouraged.

d. In developing and scheduling procedures for the conduct of this rulemaking, each agency shall satisfy its own procedural requirements.

e. Every effort shall be made to obtain a final rule which is mutually satisfactory both as to substantive content and agency jurisdiction.

V. LIMITING PROVISION

This Memorandum of Understanding shall be limited to matters pertaining to occupational safety and health in diving operations.

VI. EFFECTIVE DATE

This Memorandum of Understanding shall take effect simultaneously with the publication of the ETS in the Federal Register, and shall terminate upon the effective date of Coast Guard standards on occupational safety and health matters pertaining to diving operations. This Memorandum may be amended at any time by mutual written agreement of the Agencies and may be terminated by either agency upon thirty days notice.

Dated: June 9, 1976.

O. W. SILER,
Commandant, U.S. Coast Guard, Department of Transportation.

Dated: June 9, 1976.

MORTON CORN,
Assistant Secretary for Occupational Safety and Health, Department of Labor.

APPENDIX B—BRITISH MEDICAL RESEARCH COUNCIL TECHNIQUES

SKELETAL RADIOLOGICAL INVESTIGATION FOR DIVERS

The basic skeletal survey should include views of the head and proximal parts of the shafts of the humerus and femur on each side and projections of each knee including the distal two-thirds of the shaft of the femur and the proximal third of the shaft of the tibia.

The early demonstration of dysbaric osteonecrosis demands high quality radiographs which clearly demonstrate the bone trabeculae. This will require the optimum screen/film combination, an adequate ratio grid and a focal spot size of 1 or 1.2 mm. A smaller size with a high-speed rotating tube should be used if this is available. Gonad protection should always be used. A list of recommended projections and specimen radiographs illustrating these views should be available for the radiographer. Where possible the radiographs should be checked before the patient leaves the X-ray room or Department and preferably this should be done by the radiologist responsible for the interpretation. It is of considerable advantage to have the surveys done in as few centers as possible so that the radiography technicians become closely involved in the work and are fully aware of the problems in interpretation and the need for high quality radiographs.

SHOULDER JOINT

The objective is to obtain a radiograph of the entire articular cortex of the humeral head in unobscured profile. An 18 by 24 cm (10/8) film is recommended. An anteroposterior projection of each shoulder is taken with the patient lying supine and the trunk rotated to bring the scapula on the side to be radiographed flat against the table top. With the arm in the supine position (palm up), pulled down and abducted 10° the beam is centered one inch (24.5 mm) below the tip of the coracoid process of the scapula. The beam should be collimated by bringing in the diaphragms to show only the head and the proximal third of the shaft of the humerus. This view should show a clear joint space. The patient should hold his breath while the film is exposed.

SHOULDER JOINT WITH ARM IN INTERNAL ROTATION

An 18 by 24 cm (19/18) film is recommended. An anteroposterior projection of each shoulder joint is taken with the patient placed in a supine position and the trunk rotated to bring the scapula on the side to be radiographed flat against the table top. The humeral head is then internally rotated by turning the forearm to the prone position (palm down), with the elbow slightly flexed and the humerus abducted approximately 10°. The beam is centered 1 inch (24.5 mm) below the tip of the coracoid process of the scapula. The beam should be collimated by bringing in the diaphragms to show only the head and the proximal third of the shaft of the humerus. The patient should hold his breath during the exposure.

HIP JOINT

The objective is to obtain a radiograph demonstrating the head of the femur. To obtain comparable radiographs at serial follow-up, the femoral neck should be in a standard position. A 24 by 30 cm film (10/12) is recommended. A separate antero-posterior projection of each hip joint is taken with the patient placed in a supine position and the foot on the side under investigation kept at 90° to the table top. The beam should be centered over the head of the femur, that is, 1 inch (24.5 mm) below the mid point of the line joining the anterior-superior iliac spine and the mid point of the upper border of the pubic symphysis. The beam should be collimated by bringing in the diaphragms to show only the head, neck and immediate subtrochanteric area of the femoral shaft. The edge of the gonad protector should be as near to the femoral head as possible but not obscuring it.

KNEE JOINT

The object is to ensure a comparable density between the lower two-thirds of the femur and the upper third of the tibia. It is recommended that the kV is lowered, the mA raised and use made of a grid. Two projections are used. A 30 by 40 cm film (15/12) is recommended for both. An antero-posterior projection of each knee is made with the knee extended to include the lower two-thirds of the femur and the upper third of the tibia and fibula. The beam should be centered at the level of the upper border of the patella.

A lateral projection of each knee joint is made with the patient rotated so that the lateral border of the knee to be examined is against the table. The opposite leg should be positioned so that a line through both anterior-superior iliac spines is at right angles to the table top. In this way the projection of the knee joint is more likely to be a true lateral. The field should include the lower two-thirds of the femur and the upper third of the tibia and fibula. The beam should be centered at the level of the upper border of the patella.

Should there be doubt in the diagnosis then the following additional views may be of value.

HIP JOINT WITH LEG IN LATERAL POSITION

A 24 by 30 cm (10/12) film is recommended. A lateral projection of the hip joint increases the potential radiation dose to the gonads. However, it may be of value in identifying an early lesion particularly when there is a structural failure with a translucent subcortical band. A separate lateral projection of each hip joint is taken with the patient supine. The knee and hip on the side to be examined are flexed so that the foot is flat on the table top directly opposite the other knee. The thigh is then abducted maximally and the knee supported by a sandbag. The beam is centered over the head of the femur, that is, 1 inch (24.5 mm) below the mid point of the line joining the anterior-superior iliac spine and the upper border of the pubic symphysis. The projection should include the head, neck and immediate subtrochanteric region of the femur.

FURTHER COMMENTS

The gonads must always be protected from ionizing radiation by a lead shield. If this is done, estimation of the radiation dose received by the patient indicates that the basic skeletal survey can be safely repeated at intervals of six months.

It is debatable whether the routine surveys should include the additional projections. However, when doing this type of work, it is not always practical or easy to recall a man for a repeat or extended radiographic examination. In this situation it is worthwhile to include the additional projections as they may help to indicate more clearly whether or not an abnormality is present. When the recall is easy then the survey should be confined to the basic views.

Probably the greatest fault lies in underpenetration of the radiographs. Because of this trabecular detail is not clearly seen and consequently small dense areas close to the joint surface will not be identified. During the process of repair granulation tissue grows from the living bone into the necrotic bone and new bone is laid on the trabeculae causing an overall increase in bone bulk. Therefore, there is more tissue for the X-rays to penetrate and, unless the kilo voltage is increased possibly as much as 10 kV, a pale, underpenetrated radiograph will result. When this happens small dense areas will be identified and this is one of the commonest causes of misinterpretation and failure to identify osteonecrosis. Other difficulties in interpretation arise from malrotation of the shoulder joint resulting in the superior border of the greater tuberosity appearing as a dense layer which could be misinterpreted as osteonecrosis. Further faults will arise from inadequate projection, exposure, etc.

Tomography may be required to improve definition particularly in the femoral head and sometimes in the humeral head where detail is obscured by overlying bone. In general however, good quality radiographs preclude the need for frequent use of tomography.

(Secs. 6(c), 8(c), 84 Stat. 1596, 1599 (29 U.S.C. 655, 657); Secretary of Labor's Order No. 8-76; 29 CFR Part 1911).

Signed at Washington, D.C. this 9th day of June 1976.

MORTON CORN,
Assistant Secretary of Labor.

[FR Doc.76-17409 Filed 6-10-76;4:54 pm]